Contaminant Solubilization in Bench-scale Recirculating Ash Transport Systems

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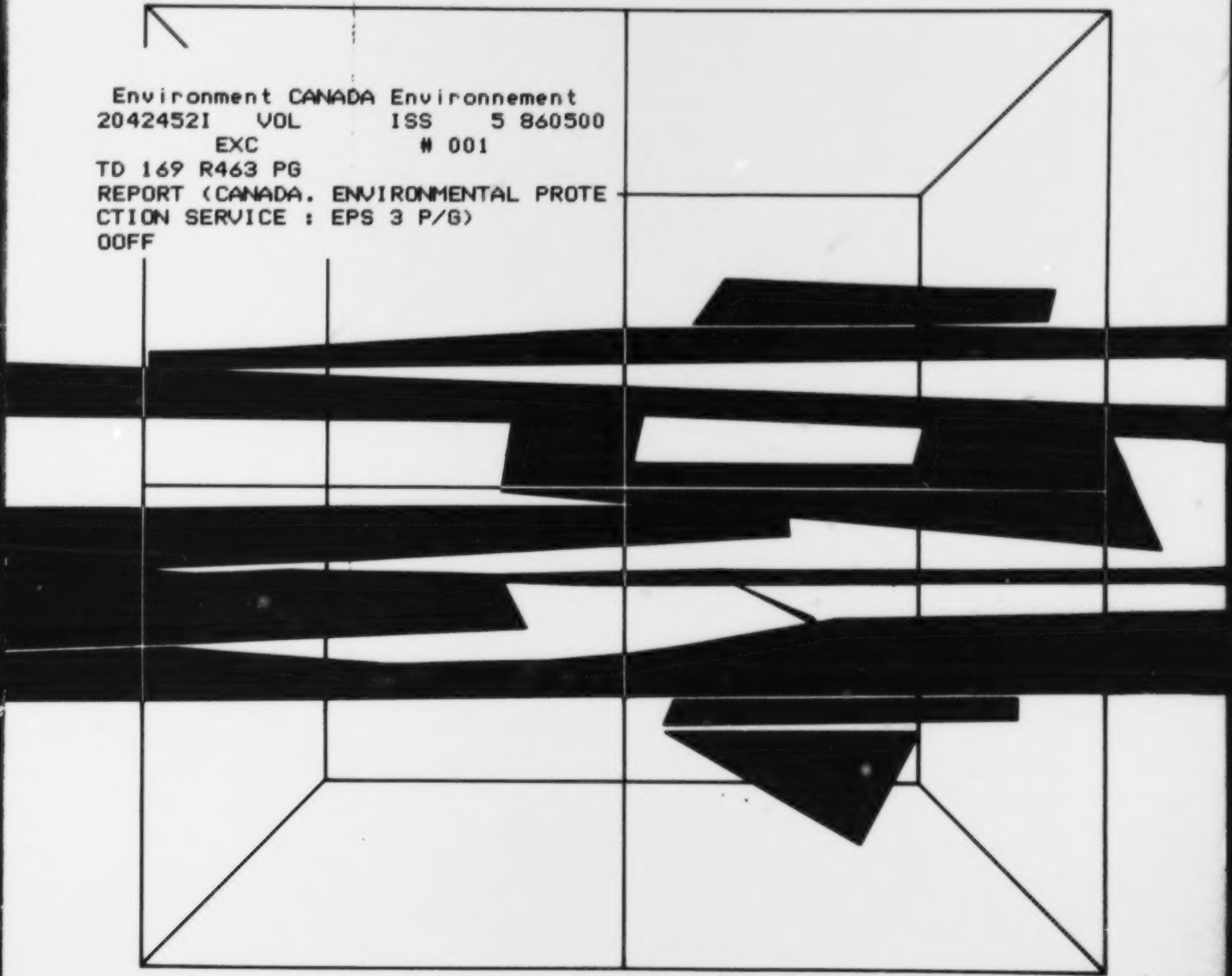

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CONTAMINANT SOLUBILIZATION IN BENCH-SCALE RECIRCULATING ASH TRANSPORT SYSTEMS

T.W. Constable and G. Ross
Environment Canada

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ABSTRACT

Bench-scale studies to simulate the operation of recirculating bottom ash and combined fly ash/bottom ash lagoons were conducted to provide information on the rate of contaminant leaching into recirculating ash sluice waters.

The ashes were obtained from seven Canadian coal-fuelled power generating stations: Dalhousie, Lingan, Lakeview, Nanticoke, Boundary Dam, Wabamum and Sundance. The concentrations of most elements in the ashes varied widely among the stations, but were often approximately the same for fly and bottom ashes from the same station.

For most ash systems, the slurry water pH reached a relatively constant value within the first two cycles of recirculation, and was generally lower in a bottom ash system than in the corresponding fly/bottom ash system.

The major dissolved species in the slurry waters were sulphate, calcium and sodium. The maximum concentrations of all detectable species, with the sole exception of magnesium, occurred in the fly/bottom ash systems.

Changes in parameter concentrations with increasing cycles of recirculation displayed wide variability among different parameters in the same ash system and also among the same parameters in different ash systems. The most frequently observed trend in bottom ash systems was an approximately linear increase in concentration with increasing cycles of recirculation. Concentrations in the fly/bottom ash systems generally increased during the first several cycles then either remained constant or decreased.

Scaling was observed only in studies involving fly/bottom ash from stations burning Western Canadian coal or a mixture of Western Canadian and U.S. bituminous coal.

RÉSUMÉ

Nous avons étudié, à échelle réduite et en simulation, les étangs de recirculation des cendres du cendrier et des cendres combinées (cendres volantes et cendres du cendrier) de sept centrales thermiques, afin de nous renseigner sur la vitesse de lixiviation des contaminants dans les eaux du circuit de recirculation.

Les centrales canadiennes à charbon d'où provenaient les cendres étaient celles de Dalhousie, de Lingan, de Lakeview, de Nanticoke, de Boundary Dam, de Wabamum et de Sundance. La concentration de la plupart des éléments constitutifs des cendres variait d'une centrale à l'autre, mais, pour une centrale donnée, elle était souvent à peu près la même dans les cendres du cendrier et les cendres volantes.

Dans la plupart des circuits, le pH de l'eau a atteint une valeur relativement constante après deux passages (cycles) et il était généralement plus bas dans le circuit des cendres du cendrier que dans celui des cendres combinées de même origine.

Les principaux ions dissous étaient les sulfates, le calcium et le sodium. Les maximums de concentration de tous les ions décelables, à l'exception du magnésium, ont été observés dans les circuits de cendres combinées.

Les variations de la concentration des différents paramètres en fonction du nombre de passages dans le même circuit ont été très larges de même que les variations de la concentration du même paramètre dans différents circuits. Le plus souvent, nous avons observé que, dans les circuits de cendres du cendrier, la concentration augmentait linéairement en fonction du nombre de passages, tandis que dans les circuits de cendres combinées, la concentration augmentait durant les premiers passages pour plafonner du décroître par la suite.

L'entartrage n'a été observé que dans la recirculation des cendres combinées de centrales brûlant du charbon de l'Ouest canadien combiné ou non à du charbon bitumineux américain.

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CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The concentrations of most parameters leached into ash sluicing water increase substantially with increasing cycles of recirculation. The concentrations of some parameters may exceed the recommended effluent quality criteria contained in the Environmental Codes of Practice for Steam Electric Power Generation. To meet these criteria, the number of recirculation cycles in some systems would have to be restricted and/or treatment of the ash sluicing water would be necessary.
2. The leachability of some parameters in recirculating ash slurry systems may be limited by solubility constraints. On a cumulative basis, the total mass discharge of these parameters will be less from recirculating systems than from once-through systems.
3. The greatest reduction in mass discharges is likely to be achieved in recirculating fly ash systems because solubility limits were achieved for more parameters in the studied fly/bottom ash systems than in the bottom ash systems.
4. The reduced volume of wastewater discharges from recirculating ash slurry systems and the higher concentrations of contaminants would make treatment of these wastewaters more efficient than treatment of once-through ash system wastewaters.
5. The wide variations in parameter behaviour among the studied ash systems indicate that the effect of recirculation on full-scale ash systems must be evaluated on a case by case basis.
6. Although predicted parameter concentrations based on mathematical modelling generally agreed well with laboratory data for major parameters, the inability to accurately predict parameter concentrations in solubility limited systems limited the utility of mathematical modelling in evaluating recirculating ash transport systems.
7. Concentrations of potential scale-forming compounds such as calcium sulphate and calcium carbonate may reach supersaturation in some recirculating ash sluicing systems. Scaling would impose a constraint on the degree of recirculation possible, particularly at stations burning Western Canada coals.

Recommendations

1. Further work should be done to determine the applicability of the results of this study to full-scale systems.

2. Further work should be done to determine the constraints imposed by scaling on full-scale recirculating ash slurry systems.
3. Future bench-scale studies of this type should be conducted using the serial batch leaching procedure instead of the more time-consuming and complex simulated ash lagoon system.

1 INTRODUCTION

A large coal-fired generating station may produce in excess of 500 000 tonnes of ash per year. Fly ash comprises 65 to 80% of the total ash, and consists of the small, light particles removed from the flue gas by air pollution control devices such as electrostatic precipitators (Costle et al., 1980). The remainder of the ash is bottom ash, which consists of the heavier, larger particles and slag which fall into a hopper at the bottom of the furnace during combustion.

At older generating stations, it is common to dispose of both fly and bottom ash by transporting it in a water slurry to a lagoon. In some older systems, decant water from the lagoon is discharged to the environment and fresh water make up is provided for each ash sluicing cycle (once-through system). These systems require large volumes of water, ranging from 30 to 90 L per kg of ash (Dearborn, 1978). In more recent systems, ash is sluiced using recycled lagoon decant water (recirculating system) and makeup water requirements are relatively small. The choice between once-through and recirculating operation of a wet system is dependent on factors such as lagoon location relative to the plant site, the quality and availability of makeup water, and discharge location which affect system economics. Environmental factors such as the effect of lagoon effluent on local water resources, regulatory requirements, and net precipitation are also taken into account (Behie et al., 1982).

Water quality in ash disposal systems is affected by ash characteristics, the quantity and quality of water used for sluicing, and the performance of the settling pond. Factors that affect ash characteristics include: the source of the coal, the method of firing, the ash fusion temperature, and the efficiency of equipment for collecting ash. The characteristics of ash pond effluents as determined by various EPA Regional Offices and the Tennessee Valley Authority (TVA) are summarized in Costle et al. (1980).

Recently developed Environmental Codes of Practice for Steam Electric Power Generation (Environment Canada, 1985) recommend a high degree of recirculation for wet ash disposal systems. However, operation of recirculating ash disposal systems can result in severe scaling or corrosion problems. As transport water is recycled, there is increased contact between the ash and sluice water. This can cause the buildup of relatively insoluble components, such as calcium carbonate (calcite), calcium sulphate (gypsum), calcium hydroxide and magnesium hydroxide, to a point where they exceed their solubility limits and scale may form. Furthermore, trace contaminant concentrations will likely be much higher in discharges from recirculating systems than from once-through systems.

The discharge of large volumes of ash sluice water containing contaminants leached from ash has been linked to concentrations of selenium found in fish, which represents a possible human health hazard (Holland, 1980). Ash leachates from Canadian coal-fired generating stations may exceed Canadian drinking water standards (Health and Welfare Canada, 1978) for boron (B), chromium (Cr) and selenium (Se) (International Joint Commission, 1979) and irrigation water standards for boron and selenium (McNeely et al., 1979). Environmental and cost considerations have resulted in recent design trends to use dry disposal (landfill) of fly ash and dewatered bottom ash, or recirculating lagoon ash disposal (Electric Power Research Institute, 1979; International Joint Commission, 1979; Burkinshaw, 1982; U.S. EPA, 1982). The feasibility of the recirculation option will be limited by the amount of blowdown required to control the buildup of scale forming components (Behie et al., 1982). The extent to which other elements are concentrated in this blowdown stream has important implications to the toxicity and possible treatment of this wastewater.

2 LITERATURE REVIEW

2.1 Coal Ash Composition

The composition of ash varies widely depending on the composition of the coal from which it is derived, boiler firing techniques, and ash collection equipment. Coal ash characteristically contains large quantities of silica (SiO_2), alumina (Al_2O_3), ferric oxide (Fe_2O_3) and smaller quantities of other oxides such as CaO, MgO, and P_2O_5 (Electric Power Research Institute, 1979; Chu et al., 1978). A large number of other elements are present in trace amounts. Elemental concentrations in fly ash and bottom ash fall within the ranges given in Table 1 (Chu et al., 1978; Cox et al., 1978; Golomb, 1978; Electric Power Research Institute, 1979; Tripodi and Cheremisinoff, 1980; U.S. EPA, 1980; Behie et al., 1982, U.S. EPA, 1982). Many elements are present in higher concentrations in fly ash than in bottom ash. The great variation seen in these data may be, in part, a result of varying analytical techniques.

Elements can be classified into three classes according to the partitioning of elements in bottom ash, fly ash, or discharged gases (Klein et al., 1975):

Class I	Elements of approximately equal concentration in the bottom ash and fly ash (Al, Ba, Ca, Ce, Co, Eu, Fe, Hf, K, La, Mg, Mn, Rb, Sc, Si, Sm, Sn, Ta, Th and Ti).
Class II	Elements which have a greater concentration in fly ash than in bottom ash (As, Cu, Ga, Pb, Sb, Se and Zn).
Class III	Elements which are primarily discharged into the atmosphere as gases (Hg, Cl and Br).

A number of other elements, such as Cr, Cs, Na, Ni, U, and V, are intermediate between Classes I and II.

Results comparable to those found in Table 1 were obtained in a study of three midwestern U.S. power plants (Radian Corp., 1975).

Partitioning may be dependent on the volatility of the elements and the state in which they are found in coal (Klein et al., 1975). During combustion the aluminosilicate matrices do not decompose but melt and coalesce, trapping the elements within them in particles which become either bottom ash or fly ash. Elements in other matrices (inorganic sulphides or organic complexes) are freed during combustion and, depending on their volatility, condense on the surface of fly ash particles as the flue gas cools or leave the stack still in the vapour phase.

TABLE 1 RANGES OF CONCENTRATIONS OF ELEMENTS IN COAL BOTTOM ASH AND FLY ASH

	Concentration (µg/g)					
Element	Bottom Ash			Fly Ash		
Ag	25			1	-	50
Al	88 000	-	135 000	11 500	-	144 000
As	0.25	-	40	2.3	-	1 700
Ba	260	-	4 000	96	-	13 500
Be	2	-	10.6	1	-	1 000
B	3.8	-	960	10	-	3 000
Ca	8 400	-	50 600	5 400	-	177 000
Cd	0.5	-	250	0.1	-	250
Co	3.6	-	380	6	-	1 500
Cr	1.3	-	895	5.5	-	7 400
Cu	2.8	-	720	16	-	3 020
Fe	27 000	-	212 000	7 800	-	289 000
Hg	< 0.01	-	4	< 0.01	-	22
K	7 300	-	15 800	1 500	-	34 700
Mg	4 500	-	32 500	4 900	-	61 000
Mn	100	-	1 000	100	-	1 000
Mo	3	-	45	6.5	-	500
Na	1 800	-	13 100	1 200	-	20 300
Ni	10	-	700	1.8	-	8 000
P	300	-	1 600	600	-	2 500
Pb	3	-	61	3.1	-	1 600
Sb	0.14	-	12	0.8	-	1 000
Se	< 0.05	-	20	< 0.05	-	760
Si	180 000	-	273 000	196 000	-	271 000
Sr	170	-	1 800	40	-	8 600
Th	12	-	15	1.8	-	68
Ti	3 300	-	7 200	400	-	15 900
U	6.8	-	14.9	0.8	-	30.1
V	25	-	670	20	-	1 180
Zn	2	-	950	14	-	13 000
Zr	220			100	-	5 000

(Chu et al., 1978; Cox et al., 1978; Golomb, 1978; Electric Power Research Institute, 1979; Tripodi and Cheremisinoff, 1980; U.S. EPA, 1980; Behie et al., 1982; U.S. EPA, 1982)

Other studies indicate that boron is more concentrated in fly ash than in bottom ash (Cox et al., 1978; Gladney et al., 1978; Behie et al., 1982). Gladney et al. (1978) found that most of the boron was released in the vapour state, and that the behaviour of boron may be classified as intermediate between Classes II and III.

The theory that certain trace elements (i.e., Class II) are vaporized and later condense or adsorb on the surface of fly ash particles suggests that enrichment in these elements should increase with decreasing fly ash particle size because of the greater surface to volume ratio of smaller particles. A number of studies indicate that such an enrichment occurs (Davison et al., 1974; Klein et al., 1975; Radian Corp., 1978; Fisher et al., 1979; Ondov et al., 1979; Phung et al., 1979; Smith et al., 1979; Hansen and Fisher, 1980). These studies show a general trend in enrichment according to the particle size of Class II elements in fly ash but some disagreement exists regarding the behaviour of individual Class I and Class II elements. This may be the result of differences in the geochemical matrix in which elements are found in different coals, boiler configuration and firing conditions, ash collection efficiencies, and particulate loading at the point of condensation of volatile materials (Radian Corp., 1978). Enrichment for some elements depends on whether hot side or cold side electrostatic precipitators (ESPs) are used (Radian Corp., 1978). A hot side ESP collects fly ash particles at a temperature above the condensation point for some elements.

2.2 Leaching

The different properties of fly and bottom ash affect the degree to which chemical constituents will dissolve in the sluice and lagoon waters. The chemical constituents in bottom ash are not as readily dissolved as those in fly ash because bottom ash is vitrified during the combustion process, it has a lower surface area per unit weight, and the elements present tend to be uniformly distributed in bottom ash particles. Fly ash particles, because of their much larger surface area per unit weight, and the concentration of elements on the surface of the ash particle, are leached at a greater rate which results in greater concentrations of their chemical constituents in the sluice and lagoon wastes.

A number of studies show increased leaching of some elements from fly ash compared to bottom ash (Radian Corp., 1975; Chu et al., 1978; Cox et al., 1978; Evers et al., 1980; Halligan and Pagenkopf, 1980). Although the elements for which increased leaching was observed varied according to the source of the ash studied, fly ashes from two or more sources showed increased leaching for: Al, As, B, Ca, Cd, Cr, Cu, Pb, Se, SO_4, and Zn. Except for aluminum, calcium and sulphate, which are normally present in high concentrations, these substances generally belong to Class II. Increased leaching with decreasing fly ash particle size has been shown for boron, sodium, magnesium and calcium (Halligan and Pagenkopf, 1980).

Methods for determining the quantitative relative concentrations of elements in the aluminosilicate matrix and in nonmatrix or surface material of coal fly ash were developed by Hansen and Fisher (1980). The fly ash samples were obtained from a large western U.S.A. coal-fired power plant that burns low-sulphur (0.5%), high-ash (20%) coal. They found that greater than 70% of the Ti, Na, K, Mg, Hf, Th and Fe is associated with the aluminosilicate matrix, whereas greater than 70% of the As, Se, Mo, Zn, Cd, W, V, U and Sb is associated with surface material on the ash particles. The elements Mn, Be, Cr, Cu, Co, Ga, Ba and Pb are intermediate in behaviour, i.e., distributed almost equally between matrix and nonmatrix material.

The water quality characteristics associated with open loop ash disposal systems depend primarily on the solubility of the ash and the characteristics of the raw water used to slurry the ash. Calcium, potassium, and sodium oxides of lignite and sub-bituminous coal ashes are readily solubilized to yield hydroxide alkalinity and high pH. In addition other salts, such as sulphates, are also readily solubilized. Contact between the ash and water, therefore, normally results in the softening of the water with the bicarbonate alkalinity in the water being converted to calcium carbonate upon contact with the ash. The process can continue as the slurry is discharged into the ash disposal lagoon. Once in the lagoon, atmospheric carbon dioxide becomes an additional source of carbonate by absorption into the alkaline water.

Elemental concentrations in water from sluicing and/or ponding of bottom ash, fly ash or combined ash fall within the ranges given in Table 2 (Radian Corp., 1975; Dreesen et al., 1977; Chu et al., 1978; International Joint Commission, 1979; Evers et al., 1980). The variability in the data may result from the factors discussed for ash composition and variables such as raw sluicing water quality, sluice water to ash ratio, contact time, pond area, and degree of recirculation of sluice water. Although laboratory scale leaching tests offer advantages in standardization of conditions, the variability in such data may also be considerable. In a study conducted by the American Society for Testing and Materials (ASTM), test results among several laboratories performing the same leaching test on the same coal ash sample varied in some cases by a factor of 1000 (Electric Power Research Institute, 1979). Laboratory leaching data, therefore, may not be useful for predicting the absolute levels of components in a specific generating station ash system. It can, however, be used to determine general trends in leaching behaviour and to identify the mechanisms controlling leaching.

TABLE 2 RANGES OF CONCENTRATIONS OF ELEMENTS IN WATER FROM ONCE-THROUGH SLUICING AND/OR PONDING OF BOTTOM ASH, FLY ASH, OR COMBINED ASH

Element	Concentration (μg/g)		
	Bottom Ash	Fly Ash	Combined Ash
Ag	< 0.000 3 - 0.000 4	< 0.01	< 0.01 - 0.01
Al	0.2 - 9.2	0.4 - 7.2	0.87 - 2.7
As	< 0.000 1 - 0.018	< 0.002 - 0.03	< 0.003 - 0.038
Ba	< 0.1 - 0.2	< 0.1 - 0.4	0.1 - 0.2
Be	0.001 - 0.002	< 0.01 - 0.01	<0.002
B	0.15 - 2.5	4 - 8.2	2.6 - 12
Ca	28 - 790	136 - 660	32 - 129
Cd	< 0.001 - 0.003	< 0.001 - 0.037	< 0.001 - 0.005
Co	< 0.003 - 0.005	<0.005	N.A.
Cr	< 0.005 - 0.12	0.02 - 0.98	0.002 - 0.043
Cu	< 0.01 - 0.65	< 0.01 - 0.31	0.003 - 0.08
Fe	< 0.05 - 5.98	< 0.05 - 1.93	< 0.03 - 2.3
Hg	< 0.000 2 - 0.001	< 0.000 2 - 0.001	0.000 2 - 0.15
K	1.7 - 1.9	20 - 23	11.6 - 12
Mg	2.9 - 68	0.02 - 14	0.4 - 21.2
Mn	< 0.01 - 0.79	< 0.01 - 0.48	< 0.005 - 0.39
Mo	0.015 - 0.056	N.A.	0.17
Na	5.4 - 6.2	18 - 20	N.A.
Ni	0.001 - 0.12	< 0.05 - 1.1	< 0.05 - 0.07
P	0.07 - 0.08	N.A.	N.A.
Pb	< 0.01 - 0.24	< 0.01 - 0.06	< 0.01 - 0.02
Sb	0.004 - 0.041	< 0.1 - 0.2	N.A.
Se	< 0.001 - 0.031	0.002 - 0.058	0.003 - 0.065
Si	2.6 - 7.7	0.59 - 12.6	3.7 - 7
Sr	N.A.	N.A.	N.A.
Th	N.A.	N.A.	N.A.
Ti	<0.1	< 1	N.A.
U	0.004 - 0.006	N.A.	N.A.
V	< 0.005 - 0.4	0.1 - 0.5	0.13
Zn	0.008 - 0.14	0.02 - 1.51	0.03 - 0.44
Zr	N.A.	N.A.	N.A.

N.A. = data not available
(Radian Corp., 1975; Dreesen et al., 1977; Chu et al., 1978; International Joint Commission, 1979; Evers et al., 1980).

2.2.1 Influence of Ash on pH of Leachate. The equilibrium pH of a number of coal ash and water mixtures studied ranged from 3.3 to 12.5 with most ash leachates having a pH in the basic range (Reed et al., 1976; Theis et al., 1976; Chu et al., 1978; Talbot et al., 1978, Halligan and Pagenkopf, 1980). Theis et al. (1976) indicated that the equilibrium pH is a function of the ratio of oxalate extractable iron to soluble calcium at pH = 3. At Fe:Ca ratios greater than 3:1 the leachate is acidic, and at ratios less than 3:1 it is basic. Alkaline ash/water mixtures characteristically show a rapid rise in pH followed by a gradual decline to equilibrium (Talbot et al., 1978).

The decline to equilibrium is more gradual if air is excluded during leaching, indicating that the decrease in pH is partly a result of dissolution of atmospheric carbon dioxide (Talbot et al., 1978). The initial increase in pH is eliminated and the pH of the leachates rises slowly to equilibrium if the leaching water contains a high bicarbonate buffering capacity (Halligan and Pagenkopf, 1980).

2.2.2 **Mechanisms of Leaching.** One model for the leaching behaviour of major elements in ash (Al, Si, Fe, Ca, Mg, K) involves the rapid dissolution of these elements and the establishment of metastable equilibria between dissolved calcium and magnesium and their solid hydroxide and carbonate phases. Metastable equilibria also develop between dissolved aluminum, silicon and iron and their solid hydrous oxide phases (Talbot et al., 1978). The nature of the solid phases is determined by pH. The equilibrium involving major components controls the solubility of trace elements by mechanisms of adsorption, discrete precipitation and co-precipitation.

A number of studies have shown there is a general trend of increasing solubility of trace metals (As, B, Cd, Co, Cr, Cu, Ni, Pb and Zn) with decreasing pH (Theis et al., 1976; Dreesen et al., 1977; Talbot et al., 1978; Phung et al., 1979; Theis and Richter, 1979). The solubility of As, Cd, Cr, Cu, Ni, Pb and Zn is controlled by adsorption on the hydrous oxides of aluminum, iron and manganese, and the adsorption capacities of these three sinks decreases with decreasing pH (Theis et al., 1976; Theis and Richter, 1979).

A study of the behaviour of trace metals from ash leachate in groundwater indicated that in a soil environment the solubility of chromium, copper, and lead may be controlled primarily by precipitation as hydroxide (Cr, Pb) or carbonate (Cu) (Theis and Richter, 1979). Under these conditions chromium solubility increases at a pH above 7.5 due to the formation of soluble hydroxo complexes such as $Cr(OH)_4$. Thus the mechanisms controlling trace element solubility may change under varying conditions within the leachate. An increase in the solubility of arsenic at high pH (12) was reported by Theis et al., (1976). At high pH arsenic is released because of the unavailability of free metal ions. Relatively high solubilities of anionic species such as As, B, F, Mo and Se at high pH have been reported (Sims and Bingham, 1968; Dreesen et al., 1977; Choi and Chen, 1979). The increase in release of boron at pH above 9 has been attributed to hydrolysis of the hydrous oxides of aluminum and iron on which it was originally adsorbed (Sims and Bingham, 1968).

2.2.3 **Influence of Time.** Data from laboratory and field studies indicate that most leaching takes place within one hour of contact between ash and water and in some cases within 15 minutes (Reed et al., 1976; Talbot et al., 1978; Evers et al., 1980; Behie et al., 1982; Cox et al., 1978). Levels of potassium and magnesium may increase slowly over several weeks and reactions involving the absorption of carbon dioxide from the atmosphere may take place over several days (Talbot et al., 1978; Halligan and Pagenkopf, 1980).

2.2.4 **Recirculation Studies.** Relatively few studies have been conducted to determine the effect of recirculation of ash sluice waters on leaching. Bench-scale studies were conducted to identify concentrations of trace metals resulting from the repeated contact of recirculated sluice water with fresh fly ash (Chu et al., 1978). Alkaline fly ash and neutral fly ash collected from the hoppers of electrostatic precipitators were used. The fly ash samples were divided into a number of bottles, mixed with river water to reach a suspended solids concentration of 30 g/L, and then shaken for 24 hours at 20°C. The water in each bottle was then filtered through a 0.45 µm membrane filter, and the filter cake discarded. Water samples from four of the bottles were analyzed chemically and assumed to represent one cycle of sluicing. To represent the second cycle of ash sluicing, fresh fly ash was added to the filtered water in the other bottles, and the shaking, filtering and analytical procedures repeated. This sequence of adding fresh fly ash to filtered water was conducted for 20 cycles. The results indicated that sulphur trioxide and calcium oxide in the fly ash easily dissolved in the water and that the concentrations of sulphate and calcium built up rapidly in the recirculated ash sluice water. In both leachates the concentrations of calcium and sulphate increased sufficiently to exceed their solubility product, indicating that supersaturation may have occurred. Potassium and sodium also were released readily into the sluice water and were independent of the pH value, whereas the leaching of magnesium and silica was dependent on pH. Chlorides dissolved only slightly.

The results indicate that solubility limiting mechanisms can limit increases in trace metal concentrations, particularly in recirculating alkaline ash transport waters. Recirculation, however, may increase some metal concentrations to many times those found in once-through systems. Concentrations of potential scale forming compounds such as calcium sulphate ($CaSO_4$) and calcium carbonate ($CaCO_3$) may reach supersaturation in recirculating ash systems.

Sequential batch leaching tests were also conducted on dust collector ash from the Poplar River plant in Saskatchewan (Behie et al., 1982). Only boron concentrations and pH were reported for each of the six serial batch tests. Boron concentrations increased during the first four cycles from 25 to 71 mg/L, then remained constant at 71 mg/L for the remaining cycles. pH values increased steadily from 11.4 to 12.3 during the six cycles. Samples taken from the ash lagoon indicated that after 9 months of operation as a recirculating system, boron concentrations had increased from 3 to 11 mg/L and the concentrations of calcium and sulphate were approaching their solubility limit. The use of a computer model to predict potential scaling in the recirculating ash system at the Keephills generating station and transient scaling problems in the partial recirculating ash system at the Nanticoke generating station were also discussed in the report.

2.2.5 Concentration of Ash in the Leaching Medium. The concentration of ash in sluicing water in 11 U.S. power plants ranged from 0.57 to 2.52 percent (Chu et al., 1978). In one laboratory study the maximum change in pH in ash/water mixtures was reached at ash concentrations of 0.1-0.2% (Theis et al., 1976). In other laboratory studies the concentrations of highly soluble elements such as sodium, potassium and chlorine appeared to increase linearly with increasing concentration of ash in water whereas the concentrations of other species such as calcium, boron, magnesium and sulphate indicated the effects of solubility limiting mechanisms (Reed et al., 1976; Elseewi et al., 1980; Halligan and Pagenkopf, 1980). These results, which indicate the effects of the dissolution of increasing quantities of ash in water, are consistent with those of the recirculation study by Chu et al. (1978).

2.2.6 Scaling. Once-through ash disposal systems do not normally experience serious scale formation because of the "purge" or blowdown provided by the relatively large once-through flow rate of ash slurry water. Effluent from once-through disposal systems is usually alkaline and contains elevated concentrations of calcium, sodium, potassium, bicarbonates, sulphates, and to a much lesser extent, chlorides, than the water used to slurry the ash (Behie et al., 1982).

Operation of recirculating ash disposal systems can result in severe scaling or corrosion problems due to the lack of "purge" or blowdown, and the resulting buildup of constituents dissolved from the ash. High concentrations of trace metals in any discharge from a recirculating system may also occur. The factors affecting scaling in recirculating ash transport systems are reviewed in Dearborn (1980).

The primary cause of scale formation is supersaturation (Cowan and Weintrett, 1976). As transport water is recycled, there is increased contact between the ash and sluice water. This can cause the buildup of relatively insoluble components, such as calcium carbonate (calcite), gypsum, calcium hydroxide, and magnesium hydroxide, to a point where they exceed their solubility limits and scale may form. Most types of scale are formed preferentially on the hottest surface in the water system since the solubility of most scale-forming minerals decreases with increasing temperature.

Potential scale-forming constituents are shown in Table 3. The major compounds are carbonates, phosphates, sulphates and silicates of calcium and magnesium. Calcite is extremely insoluble (Ksp = 6.9×10^{-9}) and tends to be the first component which approaches or exceeds solubility limits, followed by gypsum (Ksp = 1.9×10^{-5}) or calcium hydroxide (solubility = 1.9 g/L at 0°C). Under certain conditions, the precipitation of calcite will prevent the buildup of gypsum and calcium hydroxides to levels that approach their solubility limits (Behie et al., 1982).

The likelihood of scaling occurring in a recirculating water can be assessed using the limitations shown in Table 4 (Nelson, 1974). The Langelier and Ryznar Indices are commonly used to estimate the conditions under which calcium carbonate precipitation might occur (Langelier, 1936; Ryznar, 1944). These indices are only used as qualitative guidelines and are not indicative of the relative quantity of precipitation which might be expected. The basis for these indices is the equilibrium relationship between Ca^{+2}, CO_2, HCO_3^{-1}, CO_3^{-2} and pH. The Langelier Saturation Index is defined as the difference between the actual measured pH of the water and the calculated pH at saturation with calcium carbonate (pH_s): Langelier Saturation Index = $pH - pH_s$.

The value of pH_s can be calculated or determined from charts and nomographs (Sisson, 1973). A positive index indicates super-saturation and the tendency to deposit calcium carbonate. A negative index indicates under-saturation, and the tendency to dissolve any existing calcium carbonate. The water will tend to be aggressive and may corrode metals in the system, particularly if oxygen is present (Dearborn, 1983). A zero index indicates that the water is at equilibrium with respect to calcium carbonate. The Langelier Index is generally maintained between 0 and 1.

The Ryznar Stability Index, equal to $2\ pH_s - pH$, is always positive. Values near 7 are indicative of equilibrium conditions, whereas below 6 indicates scaling and above 8 indicates corrosivity. The Ryznar Index is generally maintained between 6 and 7.

TABLE 3 POTENTIAL SCALE-FORMING CONSTITUENTS (Chen et al., 1975)

Species	Name	Formula
Ca^{+2}	gypsum	$CaSO_4 \cdot 2H_2O$
	anhydrite	$CaSO_4$
	calcite	$CaCO_3$
	dolomite	$CaMg(CO_3)_2$
	tricalcium phosphate	$Ca_3(PO_4)_2$
	monetite	$CaHPO_4$
	hydroxyapatite (precipitated tricalcium phosphate)	$Ca_5OH(PO_4)_3$
Mg^{+2}	brucite	$Mg(OH)_2$
	magnesite (magnesium carbonate)	$MgCO_3$
	hydromagnesite	$Mg_4(CO_3)(OH)_2 \cdot 3H_2O$
	nesquehonite	$MgCO_3 \cdot 3H_2O$
	sepiolite	$2MgO \cdot 3SiO_2 \cdot 2H_2O$
	serpentine	$3MgO \cdot 2SiO_2 \cdot 2H_2O$
SiO_2	amorphous silica	$SiO_2 \cdot 2H_2O$
other metal oxides, carbonates and hydroxides, e.g., CuO, ZnO, $Fe(OH)_3$		

TABLE 4 OPERATIONAL CONSTRAINTS FOR RECIRCULATING WATER QUALITY (Chen et al., 1975)

Characteristic	Constraint
Calcium Carbonate	Langelier Saturation Index = 0 to 1 Ryznar Stability Index = 6 to 7
Calcium Phosphate	$(Ca)^3 \times (PO_4)^2 < 0.06$
Calcium Sulphate	$(Ca) \times (SO_4) < 577\,000$
Silica	$(SiO_2) < 150$
Magnesium and Silica	$(Mg) \times (SiO_2) < 8540$
Suspended Solids	$(SS) < 400$

Notes:

1) Langelier Saturation Index = $pH - pH_s$
Ryznar Stability Index = $2\,pH_s - pH$
where pH = measured pH
pH_s = pH at saturation with $CaCO_3$

2) (Ca), (PO_4), etc. represents the concentration of Ca, PO_4, etc. in mg/L

The other recirculating water limitations shown in Table 4 are based either on the concentrations of individual elements in the water or the product of two concentrations. Other elements in the water are not taken into consideration. Some researchers have modified this approach to more accurately reflect the conditions in operating systems and improve the techniques for predicting scale formation (Dearborn, 1983).

The degree to which components approach and exceed their solubility limits, following start-up of a recirculating system, depends primarily upon the characteristics of the ash, the quantity and characteristics of any makeup water flow, and the surface area of the ash lagoons. The surface area is important since it determines the rate at which atmospheric carbon dioxide, a source of carbonate for precipitation of calcite in recirculating systems, can transfer into the system. The rate of transfer of carbon dioxide may be insufficient to neutralize the slurry water, particularly in winter when ice cover isolates the water from the air. This results in high pH and potential for the precipitation of gypsum scale due to lack of removal of calcium as a calcite scale (Behie et al., 1982).

2.3 Organic Compounds and Radionuclides

A recent literature review indicates that 109 organic compounds have been identified in coal combustion stack emissions and that a number of polynuclear aromatic hydrocarbons (PAHs) and polychorinated biphenyls (PCBs) have been identified in fly ash (Junk and Ford, 1980). In a study of fifteen priority pollutant PAHs in eighteen samples of fly ash and bottom ash from Canadian coal-fired generating stations, all but two ashes contained very low or undetectable levels of PAH (Zenon, 1983). The two exceptions contained predominantly phenanthrene, fluoranthrene, pyrene, benzo(α)anthracene and naphthalene in concentrations less than 4 μg/g. The ashes contained very low levels (<1 μg/g) of polychlorinated dibenzofurans and undetectable levels of polychlorinated dibenzo-ρ-dioxins. In a study of liquid extracts of fly ash several varieties of polycyclic organic matter (POM) were found but they were only present at levels of 1 μg/L or less (Evers et al., 1980).

Coal contains three principle radioactive species: ^{238}U, ^{235}U and ^{232}Th, and their radioactive daughter products: ^{226}Ra, ^{228}Ra, and ^{210}Pb (Edwards et al., 1980). Of these, ^{210}Pb is the most volatile and is therefore concentrated in the fly ash or emitted with the stack gases. The others are contained in approximately equal concentrations in the fly ash and bottom ash (Coles et al., 1978).

A study of a power plant burning western U.S. coal (Stryon et al., 1981) indicated that gross alpha and gross beta activities in ash pond water (1.5 to 1.76 pCi/L

(0.06 to 0.07 Bq/L) and 3.17 to 9.10 pCi/L (0.12 to 0.34 Bq/L), respectively) were the same order of magnitude but generally less than the guidelines for Canadian Drinking Water Quality (Health and Welfare Canada, 1978). The percentage of the total activity leached from ash samples varied from 0.001% for ^{238}U to 0.07% for ^{210}Pb.

Bottom ash leachates from a number of power stations were found to contain negligible to 1.3 pCi/L (0.05 Bq/L) of ^{226}Ra, <0.1 to 2.2 pCi/L (<0.004 to 0.08 Bq/L) of ^{210}Pb, and 0.1 to 0.3 pCi/L (0.004 to 0.01 Bq/L) of ^{210}Po (Wagner et al., 1980). In the same study, fly ash leachates were found to contain negligible to 3.4 pCi/L (0.13 Bq/L) of ^{226}Ra, 0.1 to 4.7 pCi/L (0.004 to 0.17 Bq/L) of ^{210}Pb, and 0.1 to 0.8 pCi/L (0.004 to 0.03 Bq/L) of ^{210}Po. The activity of ^{210}Pb was found to increase with decreasing leachate pH.

3 BENCH-SCALE ASH RECIRCULATION EXPERIMENTS

3.1 Ash and Makeup Water Collection

Through the co-operation of power utilities, provincial environmental agencies and Environment Canada Regional offices, samples of bottom ash, fly ash and makeup water were collected from the coal-fuelled power generating stations listed in Table 5.

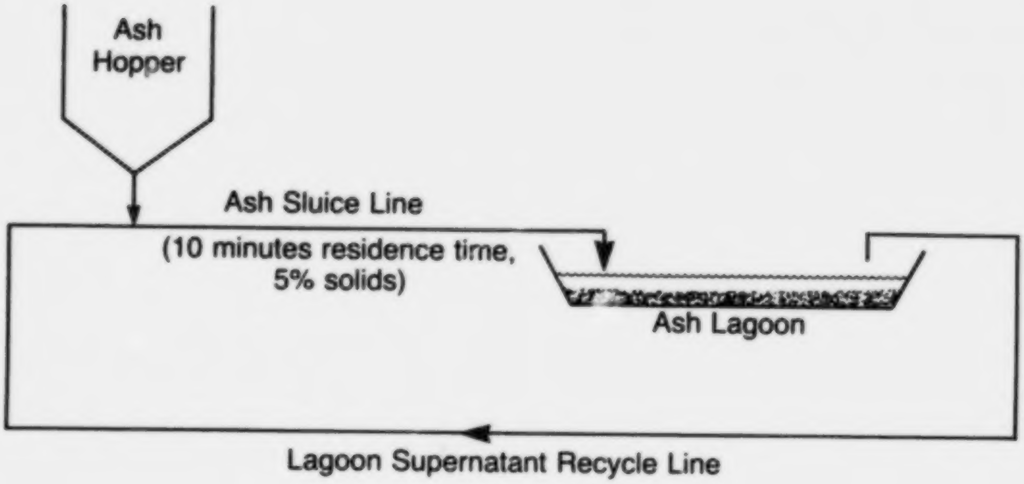
TABLE 5 SOURCE OF ASH SAMPLES

Generating Station	Type of Coal Used	Sample Collection Date
Dalhousie, New Brunswick	Eastern Canada Bituminous	March, 1981
Lingan, Nova Scotia	Eastern Canada Bituminous	December, 1980
Lakeview, Ontario	U.S. Bituminous	March, 1981
Nanticoke, Ontario	U.S. & Western Canada Bituminous	March, 1981
Boundary Dam, Saskatchewan	Western Canada Lignite	February, 1982
Wabamum, Alberta	Western Canada Sub-bituminous	December, 1980
Sundance, Alberta	Western Canada Sub-bituminous	December, 1980

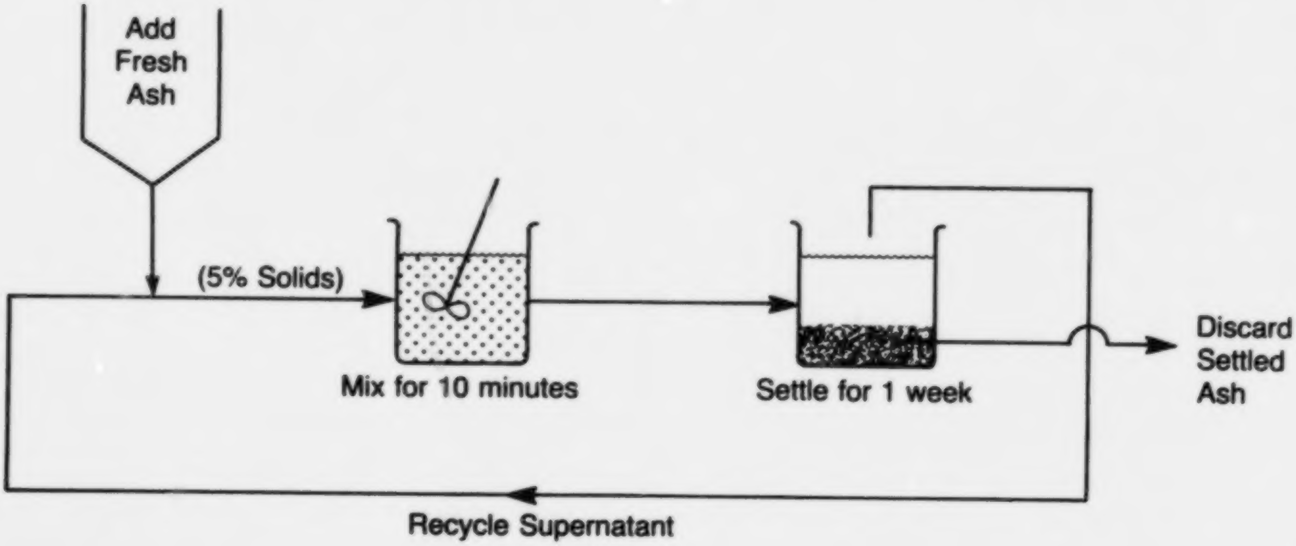
Ashes were shipped in 45-gallon (204-L) metal drums, and were transferred immediately upon receipt to sealed polyethylene tanks. Makeup waters from these stations were shipped in polyethylene containers, and were stored in these containers until required.

3.2 Experimental Procedure

Bench-scale studies were conducted at the Wastewater Technology Centre, Burlington, Ontario to simulate the operation of recirculating bottom ash and combined bottom ash/fly ash lagoons, and data was collected on the chemical constituents in the ash sluice water. The assumed recirculation system and the experimental configuration are shown in Figure 1. It was assumed that the ash slurry was 5% solids, that it required 10 minutes to transport the slurry in the ash sluice line to the lagoon, and that the settling time in the lagoon was 7 days. To simulate this system, fresh ash was added to recirculated slurry water in a ratio of 1 part ash to 19 parts water (including any water in the ash). The ash slurry was then mixed vigorously for 10 minutes and allowed to stand


Ash Hopper
Ash Sluice Line
(10 minutes residence time, 5% solids)
Ash Lagoon
Lagoon Supernatant Recycle Line

a) Recirculating sluice water system.


Add Fresh Ash
(5% Solids)
Mix for 10 minutes
Settle for 1 week
Discard Settled Ash
Recycle Supernatant

b) Procedure to simulate system in (a).

FIGURE 1 BENCH-SCALE EXPERIMENTAL SIMULATION

for 7 days. The supernatant was then decanted, sampled, and contacted with fresh ash. All studies were conducted at room temperature.

Two different ash compositions were examined for each ash source. One consisted of 100% bottom ash, and the other 75% fly ash plus 25% bottom ash (on a dry weight basis). This ratio was selected to represent the typical ratio of fly ash to bottom ash generated at a coal-fuelled power generating station.

Mixing and settling operations were performed in circular 68-L polyethylene tanks. Two tanks were used for each ash system, one for mixing and settling, and one for receiving the supernatant from the settling tank. The use of each tank alternated each week as the supernatant tank for the first week became the mixing and settling tank for the second week, etc.

The study was conducted in two phases. In Phase I, from April to September 1981, ashes from Lingan, Dalhousie, Nanticoke and Lakeview power generating stations were subjected to 20 recirculation cycles. A fifty-five litre volume of the appropriate makeup water for each ash system was used as the initial slurry water.

In Phase II, from January to October 1982, ashes from Boundary Dam, Sundance and Wabamum stations were subjected to 30 recirculation cycles. Ten extra cycles were added in Phase II to examine the continuation of trends past the 20 cycles used in Phase I. Only 40 litres of makeup water were used in Phase II because of limited ash quantities and the additional ash requirements imposed by the extra 10 cycles.

The following experimental procedure was carried out each week for each ash system:

1. The pH and conductivity of the slurry water were recorded.
2. The volume of slurry water lost by evaporation was determined.
3. An aliquot of slurry water was collected. Sample volumes ranged between 50 and 1060 mL, depending on analytical requirements.
4. The slurry water was syphoned into the second tank. Syphoning was stopped just prior to disturbance of the settled ash.
5. The balance of the slurry water was decanted into graduated cylinders. This water was allowed to settle (approximately 5 to 30 minutes), and then decanted into the second tank. This procedure was followed to minimize transfer of contacted ash into subsequent cycles.
6. Distilled water was added to the second tank to make up the loss to evaporation, as determined by Step 2.

7. A 200 mL aliquot of slurry water was collected, filtered through Whatman GF/C filter paper, and analyzed for suspended solids (to determine if any transfer of ash has occurred during the syphoning and decanting operations), dissolved solids and alkalinity. This step was conducted weekly during Phase I, and bi-weekly during Phase II.
8. Bottom ash or bottom/fly ash (at 75% fly ash and 25% bottom ash, on a dry weight basis) was added to the water in the ratio of 1 part ash (dry weight) to 19 parts water (including any water in the ash).
9. The ash slurry was mixed for 10 minutes using a Model 11 "Lightnin" Mixer, with a stainless steel shaft and propeller, at low speed.
10. Conductivity and pH were recorded at elapsed times of 0, 1, 10, 30 and 60 minutes after starting the mixer. They were also recorded at the end of every working day.
11. The mixer was removed from the tank, and the tank partially covered to decrease evaporation loss but also allow fresh air contact with the water.
12. The water level was marked on the outside of the tank to allow the volume of water lost to evaporation during the weekly cycle to be determined (see Step 2).

3.3 Solid and Liquid Analyses

3.3.1 **Ash.** Composite samples of bottom and fly ash were dried and ground to -100 mesh prior to submission to Barringer Magenta Ltd., where they were dissolved in hydrofluoric acid and analyzed by Inductively Coupled Plasma (ICP) for the elements listed in Table 6. Ash samples were also analyzed at the WTC laboratory for radium-226, thorium-228, thorium-230, thorium-232 and lead-210.

For quality assurance testing, two samples of each ash were analyzed by the Barringer laboratory, and one sample of each ash was analyzed for selected elements by the WTC laboratory.

3.3.2 **Slurry Water.** Aliquots of slurry water were collected from each ash system at the beginning of the study (prior to any ash addition) and at the end of each weekly cycle. These samples were filtered (0.45 μm), preserved if necessary, and analyzed by the Barringer and WTC laboratories for the elements and parameters listed in Table 6. Additional samples were periodically analyzed by the WTC laboratory for some of the elements measured by the Barringer laboratory. Further quality assurance testing was done by randomly submitting duplicate samples, spiked samples, standards and/or blanks to both laboratories for analysis.

TABLE 6 ANALYTICAL METHODS AND DETECTION LIMITS

Analyzed by Barringer Magenta Ltd. Laboratory			
Elements and Parameters	Method	Detection Limits* Ash**	 Slurry Water
Ag	I.C. Plasma***	0.5	0.005
Al	I.C. Plasma***	5	0.01
B	I.C. Plasma***	0.005	0.005
Ba	I.C. Plasma***	0.005	0.005
Be	I.C. Plasma***	0.05	0.000 5
Ca	I.C. Plasma***	5	0.05
Cd	I.C. Plasma***	10	0.01
Co	I.C. Plasma***	5	0.05
Cr	I.C. Plasma***	1	0.01
Cu	I.C. Plasma***	0.5	0.008
Fe	I.C. Plasma***	1	0.01
K	I.C. Plasma***	100	1
Mg	I.C. Plasma***	1	0.01
Mn	I.C. Plasma***	1	0.01
Mo	I.C. Plasma***	30	0.3
Na	I.C. Plasma***	2	2
Ni	I.C. Plasma***	0.05	0.05
P	I.C. Plasma***	0.5	0.6
Pb	I.C. Plasma***	5	0.05
Si	I.C. Plasma***	0.05	0.05
Sr	I.C. Plasma***	0.001	0.001
Th	I.C. Plasma***	0.01	0.01
Ti	I.C. Plasma***	0.005	0.005
V	I.C. Plasma***	0.005	0.005
Zn	I.C. Plasma***	0.05	0.05
Zr	I.C. Plasma***	0.02	0.05
U	Fluorescence	0.000 2	0.000 2
Analyzed by Wastewater Technology Centre Laboratory			
As	Graphite Furnace		0.002
Cl	Automated Mercuric Thiocyanate		0.05
Hg	Mercury Analyzer		0.1
Sb	D.C. Plasma		0.003
Se	Graphite Furnace		0.003
SO_4	Automated Methyl Thymol Blue		1.
Tl	Graphite Furnace		0.005
Alkalinity	Potentiametric Titration		1.0
Conductivity	Meter		±0.2
pH	Meter		±0.1
Suspended Solids	Gravimetric		10.0
Dissolved Solids	Gravimetric		10.0

* all detection limits are in ppm (mg/L) for waters and µg/g for ashes, except for conductivity (mS/cm) and pH (units)

** ash samples were ground to -100 mesh prior to analysis

*** dissolution in hydrofluoric acid

The conductivity and pH of the slurry waters were recorded several times during the first hour of each mixing cycle and also once a day on each working day.

At the end of the 20 or 30 week experimental period, slurry water from each ash system was analyzed by the WTC laboratory for dissolved gross alpha (α), gross beta (β), ^{226}Ra, ^{210}Pb, ^{228}Th, ^{230}Th and ^{232}Th, and for suspended gross α and β. Four slurry waters (Dalhousie, Lingan and Lakeview bottom ash systems, and Nanticoke fly/bottom ash system) were also analyzed for base/neutral and acid-extractable priority pollutants.

3.4 Results

3.4.1 Ash and Makeup Water Compositions. Elemental analyses of makeup waters, bottom ashes and fly ashes from the seven stations are given in Tables 7 to 13. The compositions of the 75% fly ash/25% bottom ash mixtures were not determined by analyses, but were calculated from the fly and bottom ash analytical results.

The bottom ash and fly ash compositions for the seven stations are compared in Tables 14 and 15. In general, the predominant elements in both the bottom and fly ashes were Si, Al, Fe, Ca, Na, Mg, Ti, Ba, K, P, Mn and Sr. The concentrations of most elements varied widely among the stations, but were often approximately the same for fly and bottom ashes from the same station. Exceptions included concentrations of: B, Ba, Ca, Cu, P, Pb and Zn which were usually higher in the fly ash than the bottom ash from the same station.

The results of the radiochemical analyses of the coal ashes are given in Table 16. In general, radionuclide levels were highest in Western sub-bituminous ashes and lowest in U.S. bituminous and Western lignite ashes. Radium-226 levels were below the detection limit in the Dalhousie, Lakeview, Nanticoke and Boundary Dam ashes. Radium-226 levels in the other ashes ranged between 13 and 105 pCi/g (0.48 and 3.89 Bq/g). Thorium levels, except for the Wabamum ashes, were generally below or near the detection limit. Lead-210 levels were below the detection limit in all ashes.

3.4.2 Ash Slurry Water Compositions. The results of the slurry water analysis program are presented in the Appendix, and plots for the major parameters are given in Figures 2 to 15. Non-detectable parameter concentrations were plotted at half the detection limit. The values shown in Cycle 0 indicate concentrations in the makeup waters prior to ash addition. Total suspended solids concentrations in all water samples were generally less than 30 mg/L, indicating that very little undissolved ash was transferred in the slurry waters into subsequent recirculation cycles.

TABLE 7 ELEMENTAL ANALYSES OF DALHOUSIE BOTTOM ASH, FLY ASH AND MAKEUP WATER

Element or Parameter	Makeup Water	Bottom Ash	Fly Ash	Fly/Bottom Ash*
Ag	< 0.005	< 0.05	< 0.5	< 0.5
Al	< 0.01	66 800	76 200	73 900
B	0.046	10	33	27
Ba	0.118	406	478	460
Be	< 0.000 5	7.9	10.0	9.5
Ca	81	33 200	29 800	30 700
Cd	< 0.01	5.5	2.8	3.5
Cl	14	--	--	--
Co	< 0.05	< 5	< 5	< 5
Cr	< 0.01	5.4	18	15
Cu	< 0.008	116	162	151
Fe	0.05	313 000	298 000	302 000
K	3	11 500	15 100	14 200
Mg	2.29	3 310	3 440	3 410
Mn	< 0.01	1 840	1 670	1 710
Mo	< 0.3	< 30	< 30	< 30
Na	35	1 590	1 770	1 730
Ni	< 0.05	75	77	76
P	< 0.6	4 580	6 180	5 780
Pb	< 0.05	< 5	24	19
Se	< 0.003	--	--	--
Si	2.2	180 000	176 000	177 000
Sr	0.215	250	266	262
Th	0.06	9	12	11
Ti	< 0.005	3 660	3 660	3 660
U	0.002 2	6.5	8.0	7.6
V	< 0.005	167	194	187
Zn	< 0.05	58	170	142
Zr	< 0.05	203	153	166
SO_4	130	--	--	--
TDS	130	--	--	--
pH	7.7	--	--	--
Conductivity	0.55	--	--	--

NOTE: all results reported in ppm (mg/L) except pH (units) and conductivity (mS/cm)

* calculated as a mixture of 75% fly ash and 25% bottom ash

TABLE 8 ELEMENTAL ANALYSES OF LINGAN BOTTOM ASH, FLY ASH AND MAKEUP WATER

Element or Parameter	Makeup Water	Bottom Ash	Fly Ash	Fly/Bottom Ash*
Ag	< 0.005	< 0.05	< 0.05	< 0.5
Al	2.75	130 000	131 000	131 000
B	0.795	24	79	65
Ba	0.199	652	634	639
Be	< 0.000 5	6.1	9.7	8.8
Ca	101	4 660	5 650	5 400
Cd	< 0.01	3.7	2.0	2.4
Cl	23	--	--	--
Co	< 0.05	< 5	< 5	< 5
Cr	< 0.01	80	85	84
Cu	0.067	72	131	116
Fe	0.06	162 000	166 000	165 000
K	30	29 800	29 400	29 500
Mg	7.9	8 720	7 970	8 160
Mn	1.21	613	546	563
Mo	< 0.3	< 30	< 30	< 30
Na	35	5 270	5 580	5 500
Ni	0.08	91	109	105
P	< 0.6	520	790	723
Pb	< 0.05	28	325	251
Se	< 0.003	--	--	--
Si	3.6	217 000	217 000	217 000
Sr	0.445	289	350	335
Th	0.06	19	22	21
Ti	< 0.005	4 950	5 150	5 100
U	0.001 8	5.0	4.5	4.6
V	< 0.005	170	205	196
Zn	0.18	119	601	481
Zr	< 0.05	179	182	181
SO_4	280	--	--	--
TDS	600	--	--	--
pH	4.35	--	--	--
Conductivity	0.80	--	--	--

NOTE: all results reported in ppm (mg/L) except pH (units) and conductivity (mS/cm)

* calculated as a mixture of 75% fly ash and 25% bottom ash

TABLE 9 ELEMENTAL ANALYSES OF LAKEVIEW BOTTOM ASH, FLY ASH AND MAKEUP WATER

Element or Parameter	Makeup Water	Bottom Ash	Fly Ash	Fly/Bottom Ash*
Ag	< 0.005	< 0.5	< 0.5	< 0.5
Al	< 0.01	120 000	127 000	125 000
B	0.031	100	464	373
Ba	0.143	1 610	835	1 030
Be	< 0.000 5	8.5	10.5	10.0
Ca	38.8	23 800	26 200	25 600
Cd	< 0.01	3.2	1.8	2.2
Cl	30	--	--	--
Co	< 0.05	< 5	< 5	< 5
Cr	< 0.01	92	124	116
Cu	0.009	71	76	75
Fe	0.05	197 000	110 000	132 000
K	5	11 500	12 800	12 500
Mg	8.23	5 070	5 290	5 240
Mn	< 0.01	384	225	265
Mo	< 0.3	< 30	< 30	< 30
Na	15	4 860	6 130	5 810
Ni	< 0.05	91	99	97
P	< 0.6	730	1 120	1 020
Pb	< 0.05	21	36	32
Se	< 0.003	--	--	--
Si	< 0.05	220 000	216 000	217 000
Sr	0.158	1 040	1 190	1 150
Th	0.02	18	18	18
Ti	< 0.005	6 160	6 410	6 350
U	0.001 6	8.0	15	13
V	< 0.005	152	224	206
Zn	0.11	75	124	112
Zr	< 0.05	268	202	219
SO_4	21	--	--	--
TDS	200	--	--	--
pH	7.3	--	--	--
Conductivity	0.30	--	--	--

NOTE: all results reported in ppm (mg/L) except pH (units) and conductivity (mS/cm)

* calculated as a mixture of 75% fly ash and 25% bottom ash

TABLE 10 ELEMENTAL ANALYSES OF NANTICOKE BOTTOM ASH, FLY ASH AND MAKEUP WATER

Element or Parameter	Makeup Water	Bottom Ash	Fly Ash	Fly/Bottom Ash*
Ag	< 0.005	< 0.5	< 0.5	< 0.5
Al	< 0.01	119 000	126 000	124 000
B	0.113	116	449	366
Ba	0.096	1 080	2 810	2 380
Be	< 0.000 5	8.4	6.8	7.2
Ca	59.7	27 100	51 900	45 700
Cd	< 0.01	2.8	2.4	2.5
Cl	41	--	--	--
Co	< 0.05	< 5	< 5	< 5
Cr	< 0.01	92	61	69
Cu	< 0.008	71	77	76
Fe	0.01	200 000	75 400	107 000
K	13	10 700	9 280	9 640
Mg	9.60	5 300	6 340	6 080
Mn	< 0.01	409	410	410
Mo	< 0.3	< 30	< 30	< 30
Na	54	4 760	5 170	5 070
Ni	< 0.05	89	52	61
P	< 0.6	775	1 090	1 010
Pb	< 0.05	< 5	39	30
Se	0.022	--	--	--
Si	0.30	216 000	247 000	239 000
Sr	0.284	987	1 080	1 060
Th	0.03	20	18	19
Ti	< 0.005	5 930	6 480	6 340
U	0.002 8	5.0	4.0	5
V	< 0.005	170	151	156
Zn	< 0.05	68	93	87
Zr	< 0.05	242	291	279
SO_4	810	--	--	--
TDS	--	--	--	--
pH	7.8	--	--	--
Conductivity	0.63	--	--	--

NOTE: all results reported in ppm (mg/L) except pH (units) and conductivity (mS/cm)

* calculated as a mixture of 75% fly ash and 25% bottom ash

TABLE 11 ELEMENTAL ANALYSES OF BOUNDARY DAM BOTTOM ASH, FLY ASH AND MAKEUP WATER

Element or Parameter	Makeup Water	Bottom Ash	Fly Ash	Fly/Bottom Ash*
Ag	< 0.005	< 0.5	< 0.5	< 0.5
Al	< 0.01	103 000	122 000	117 000
B	2.76	626	973	886
Ba	0.311	10 800	11 100	11 000
Be	< 0.000 5	7.6	6.0	6.4
Ca	68.4	121 000	131 000	129 000
Cd	< 0.01	3.9	3.6	3.7
Cl	32.5	--	--	--
Co	< 0.05	< 5	< 5	< 5
Cr	0.62	32	35	34
Cu	< 0.008	59	53	55
Fe	0.10	30 700	20 100	22 800
K	17	4 730	2 730	3 230
Mg	32.2	21 600	26 100	25 000
Mn	< 0.01	122	187	171
Mo	< 0.3	< 30	< 30	< 30
Na	199	36 700	42 600	41 100
Ni	< 0.05	21	20	20
P	< 0.6	1 260	2 920	2 500
Pb	< 0.05	19	72	59
Se	< 0.005	--	--	--
Si	< 0.05	188 000	188 000	188 000
Sr	1.66	1 830	1 980	1 940
Th	< 0.01	< 1	< 1	< 1
Ti	< 0.05	3 720	4 470	4 280
U	0.001 4	11.5	13.5	13.0
V	< 0.005	57	64	62
Zn	< 0.05	21	25	24
Zr	< 0.05	259	278	273
SO_4	318	--	--	--
TDS	1 010	--	--	--
pH	8.25	--	--	--
Conductivity	1.08	--	--	--

NOTE: all results reported in ppm (mg/L) except pH (units) and conductivity (mS/cm)

* calculated as a mixture of 75% fly ash and 25% bottom ash

TABLE 12 ELEMENTAL ANALYSES OF WABAMUM BOTTOM ASH, FLY ASH AND MAKEUP WATER

Element or Parameter	Makeup Water	Bottom Ash	Fly Ash	Fly/Bottom Ash*
Ag	0.256	< 0.5	< 0.5	< 0.5
Al	0.16	84 400	100 000	96 100
B	0.697	268	442	399
Ba	0.105	2 030	3 150	2 870
Be	< 0.000 5	4.1	6.1	5.6
Ca	24.0	80 800	91 600	88 900
Cd	0.20	3.8	4.7	4.5
Cl	4.7	--	--	--
Co	< 0.05	17	25	23
Cr	0.02	23	33	31
Cu	< 0.005	34	42	40
Fe	0.02	31 500	28 700	29 400
K	9	3 740	6 250	5 620
Mg	15.75	7 550	9 540	9 040
Mn	< 0.01	556	702	666
Mo	< 0.2	< 30	46	35 to 42
Na	48	2 180	2 840	2 680
Ni	< 0.05	30	37	35
P	0.7	630	710	690
Pb	0.10	6	40	32
Se	0.013	--	--	--
Si	1.55	367 000	291 000	310 000
Sr	0.247	250	327	308
Th	0.02	23	25	24
Ti	< 0.005	2 840	3 520	3 350
U	< 0.001 0	18.5	17.5	17.8
V	0.006	62	87	81
Zn	< 0.05	18	40	35
Zr	< 0.02	223	275	262
SO_4	29	--	--	--
TDS	250	--	--	--
pH	8.45	--	--	--
Conductivity	0.35	--	--	--

NOTE: all results reported in ppm (mg/L) except pH (units) and conductivity (mS/cm)

* calculated as a mixture of 75% fly ash and 25% bottom ash

TABLE 13 ELEMENTAL ANALYSES OF SUNDANCE BOTTOM ASH, FLY ASH AND MAKEUP WATER

Element or Parameter	Makeup Water	Bottom Ash	Fly Ash	Fly/Bottom Ash*
Ag	0.082	< 0.5	< 0.5	< 0.5
Al	< 0.05	121 000	127 000	126 000
B	0.945	126	259	226
Ba	0.290	161	5 750	4 350
Be	< 0.000 5	5.7	7.3	6.9
Ca	48.1	68 700	105 000	95 900
Cd	0.20	4.2	5.1	4.9
Cl	14.1	--	--	--
Co	< 0.05	10	24	21
Cr	0.02	16.7	37	32
Cu	0.013	32	53	48
Fe	0.06	19 900	25 700	24 300
K	7	3 630	6 350	5 670
Mg	27.2	3 700	6 540	5 830
Mn	< 0.01	377	389	386
Mo	< 0.2	21	38	34
Na	70	12 500	22 500	20 000
Ni	< 0.05	16	25	23
P	0.9	690	830	795
Pb	0.15	9	55	44
Se	0.005	--	--	--
Si	4.09	354 000	338 000	342 000
Sr	0.931	750	1 020	950
Th	0.01	29	30	30
Ti	< 0.005	3 110	3 910	3 710
U	0.003 0	6.5	9.5	8.8
V	< 0.005	51	91	81
Zn	0.08	28	74	63
Zr	< 0.02	281	365	344
SO_4	145	--	--	--
TDS	460	--	--	--
pH	8.65	--	--	--
Conductivity	0.65	--	--	--

NOTE: all results reported in ppm (mg/L) except pH (units) and conductivity (mS/cm)

* calculated as a mixture of 75% fly ash and 25% bottom ash

TABLE 14 COMPARISON OF BOTTOM ASH COMPOSITIONS

Element	Dalhousie	Lingan	Lakeview	Nanticoke	B. Dam	Wabamum	Sundance
Al	66 800	130 000	120 000	119 000	103 000	84 400	121 000
B	10	24	100	116	626	268	126
Ba	406	652	1 610	1 080	10 800	2 030	161
Be	7.9	6.1	8.5	8.4	7.6	4.1	5.7
Ca	33 200	4 660	23 800	27 100	121 000	80 800	68 700
Cd	5.5	3.7	3.2	2.8	3.9	3.8	4.2
Cr	5.4	80	92	92	32	23	16.7
Cu	116	72	71	71	59	34	32
Fe	313 000	162 000	197 000	200 000	30 700	31 500	19 900
K	11 500	29 800	11 500	10 700	4 730	3 740	3 630
Mg	3 310	8 720	5 070	5 300	21 600	7 550	3 700
Mn	1 840	613	384	409	122	556	377
Na	1 590	5 270	4 860	4 760	36 700	2 180	12 500
Ni	75	91	91	89	21	30	16
P	4 580	520	730	775	1 260	630	690
Pb	< 5	28	21	< 5	19	6	9
Si	180 000	217 000	220 000	216 000	188 000	367 000	354 000
Sr	250	289	1 040	987	1 830	250	750
Th	9	19	18	20	< 1	23	29
Ti	3 660	4 950	6 160	5 930	3 720	2 840	3 110
U	6.5	5.0	8.0	5.0	11.5	18.5	6.5
V	167	170	152	170	57	62	51
Zn	58	119	75	68	21	18	28
Zr	203	179	268	242	259	223	281
Type of coal*	E.B.	E.B.	U.S.B.	U.S.&W.B.	W.L.	W.S.B.	W.S.B.

* E.B. = Eastern Bituminous
U.S.B. = U.S. Bituminous
U.S.&W.B. = U.S. and Western Bituminous
W.L. = Western Lignite
W.S.B. = Western Sub-bituminous

all results reported in ppm (µg/g)

TABLE 15 COMPARISON OF FLY ASH COMPOSITIONS

Element	Dalhousie	Lingan	Lakeview	Nanticoke	B. Dam	Wabamum	Sundance
Al	76 200	131 000	127 000	126 000	122 000	100 000	127 000
B	33	79	464	449	973	442	259
Ba	478	634	835	2 810	11 100	3 150	5 750
Be	10.0	9.7	10.5	6.8	6.0	6.1	7.3
Ca	29 800	5 650	26 200	51 900	131 000	91 600	105 000
Cd	2.8	2.0	1.8	2.4	3.6	4.7	5.1
Cr	18	85	124	61	35	33	37
Cu	162	131	76	77	53	42	53
Fe	298 000	166 000	110 000	75 400	20 100	28 700	25 700
K	15 100	29 400	12 800	9 280	2 730	6 250	6 350
Mg	3 440	7 970	5 290	6 340	26 100	9 540	6 540
Mn	1 670	546	225	410	187	702	389
Na	1 770	5 580	6 130	5 170	42 600	2 840	22 500
Ni	77	109	99	52	20	37	25
P	6 180	790	1 120	1 090	2 920	710	830
Pb	24	325	36	39	72	40	55
Si	176 000	217 000	216 000	247 000	188 000	291 000	338 000
Sr	266	350	1 190	1 080	1 980	327	1 020
Th	12	22	18	18	< 1	25	30
Ti	3 660	5 150	6 410	6 480	4 470	3 520	3 910
U	8.0	4.5	15	4.0	13.5	17.5	9.5
V	194	205	224	151	64	87	91
Zn	170	601	124	93	25	40	74
Zr	153	182	202	291	278	275	365
Type of coal*	E.B.	E.B.	U.S.B.	U.S.&W.B.	W.L.	W.S.B.	W.S.B.

* E.B. = Eastern Bituminous
U.S.B. = U.S. Bituminous
U.S.&W.B. = U.S. and Western Bituminous
W.L. = Western Lignite
W.S.B. = Western Sub-bituminous

all results reported in ppm (μg/g)

TABLE 16 RADIOCHEMICAL ANALYSES OF ASHES

Ash	^{226}Ra (pCi/g)	^{226}Ra (Bq/g)	^{228}Th (pCi/g)	^{228}Th (Bq/g)	^{230}Th (pCi/g)	^{230}Th (Bq/g)	^{232}Th (pCi/g)	^{232}Th (Bq/g)	^{210}Pb (pCi/g)	^{210}Pb (Bq/g)
Dalhousie Bottom	N.D.		1	0.04	14	0.52	<1	<0.04	<10	<0.37
Dalhousie Fly	< 1	<0.04	2	0.07	2	0.07	<1	<0.04	<10	<0.37
Lingan Bottom	28	1.04	<1	<0.04	<1	<0.04	<1	<0.04	N.A.	
Lingan Fly	13	0.48	<1	<0.04	<1	<0.04	<1	<0.04	N.A.	
Lakeview Bottom	N.D.		N.A.		N.A.		N.A.		<10	<0.37
Lakeview Fly	N.D.		9	0.33	<1	<0.04	<1	<0.04	<10	<0.37
Nanticoke Bottom	N.D.		<1	<0.04	<1	<0.04	<1	<0.04	<10	<0.37
Nanticoke Fly	N.D.		<1	<0.04	<1	<0.04	<1	<0.04	<10	<0.37
B. Dam Bottom	N.D.		<1	<0.04	<1	<0.04	<1	<0.04	<10	<0.37
B. Dam Fly	N.D.		7	0.26	7	0.26	3	0.11	<10	<0.37
Sundance Bottom	22	0.81	<1	<0.04	<1	<0.04	<1	<0.04	N.A.	
Sundance Fly	105	3.89	3	0.11	2	0.07	1	0.04	N.A.	
Wabamum Bottom	55	2.04	10	0.37	14	0.52	5	0.19	N.A.	
Wabamum Fly	21	0.78	16	0.59	39	1.44	10	0.37	N.A.	

N.A. = not analyzed
N.D. = not detected

Dalhousie Ash Systems. Slurry water pH in the Dalhousie bottom ash system decreased slightly from 7.8 to 7.1 during the 20 cycle study period (Figure 2). All detectable parameters, with the exception of alkalinity, increased during the study. Calcium, magnesium, sodium and strontium concentrations increased linearly. Conductivity, potassium, silicon, sulphate and total dissolved solids concentrations fluctuated but generally also increased linearly. Manganese concentrations increased linearly to Cycle 16, then increased more rapidly during the last four cycles. The continual increase in the concentrations of these parameters indicate that their solubility limits were not achieved. The main contributors to total dissolved solids were calcium and sulphate. No scaling was observed in the system.

Slurry water pH in the Dalhousie fly/bottom ash system decreased from 7.7 to 5.1 during the first 3 cycles, remained relatively constant up to Cycle 13, then steadily increased to reach 7.2 at Cycle 20 (Figure 3). Maximum concentrations in this system were usually higher than those in the bottom ash system, as shown in Table 17. Most detectable parameters increased rapidly during the first several cycles, then either remained relatively constant for the balance of the study or decreased, suggesting that solubility limits were either achieved or exceeded. Those that remained fairly constant included conductivity, magnesium, potassium and total dissolved solids. Those that decreased included arsenic, calcium, copper, manganese, molybdenum, phosphorus, silicon and thallium. Sulphate concentrations also increased rapidly during the first several cycles, but continued to increase for the balance of the study at a slower rate. The major contributors to total dissolved solids were calcium and sulphate. No scaling was observed in the system.

Lingan Ash Systems. Slurry water pH in the Lingan bottom ash system decreased slightly from 4.4 to 3.7 during the 20 cycle study (Figure 4). As shown in Table 17, higher concentrations of many elements (e.g., Al, B, Fe, K, Mn, Ni and Si) were achieved in this system than in the Dalhousie bottom ash system. This occurred because of the lower slurry water pH and the higher concentrations of these elements (with the exceptions of iron and manganese) in the Lingan bottom ash (Table 14). Most parameters increased during the study, with many of them increasing linearly during the first 11 to 14 cycles then levelling off, suggesting that solubility limits had been achieved. The parameters following this pattern were conductivity, total dissolved solids, aluminum, calcium, magnesium, manganese, nickel, potassium and strontium. Boron, cobalt, sodium, sulphate and zinc concentrations fluctuated but overall showed an increasing trend. Silicon concentrations increased steadily throughout the study. Copper and iron

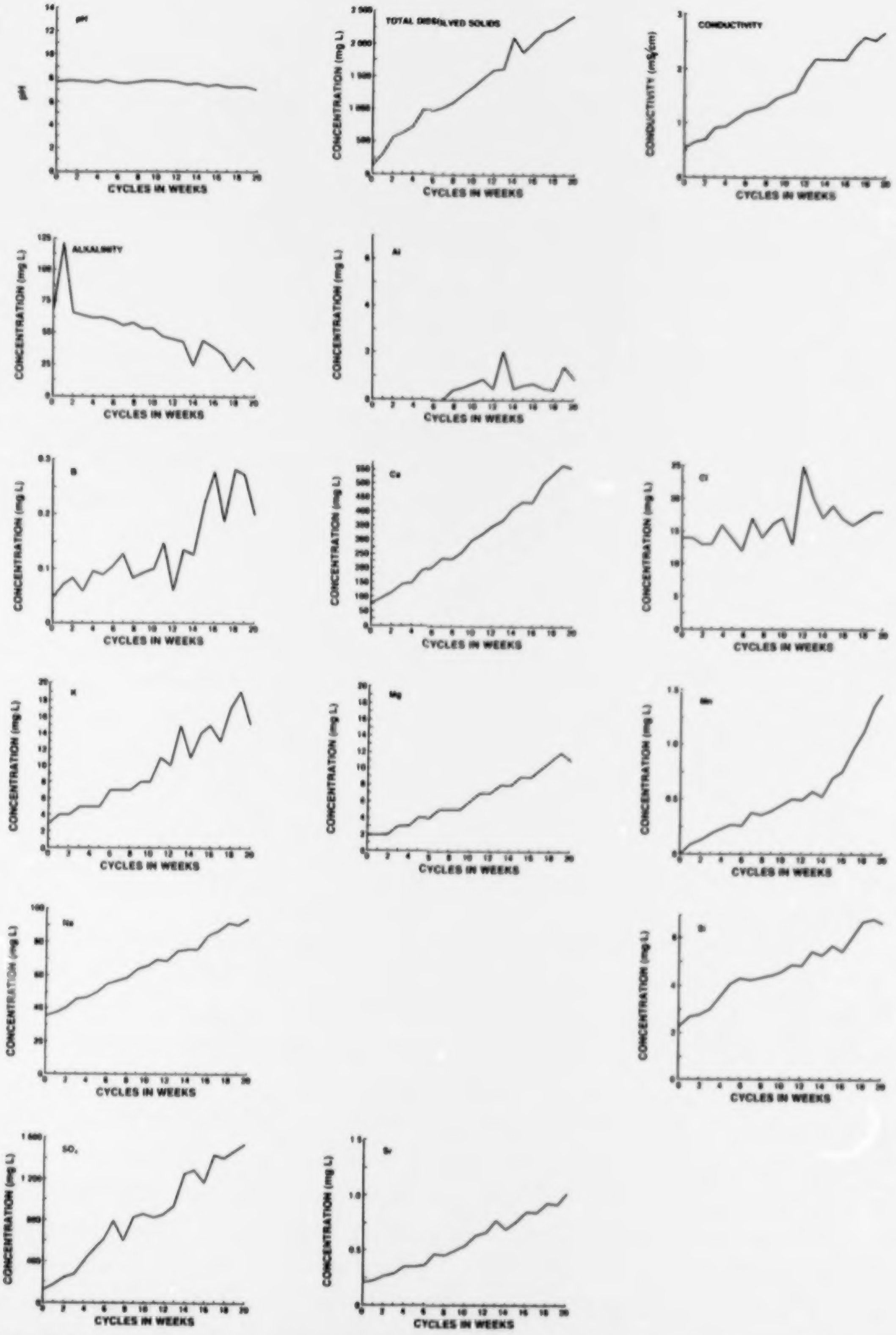


FIGURE 2 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN DALHOUSIE BOTTOM ASH SYSTEM

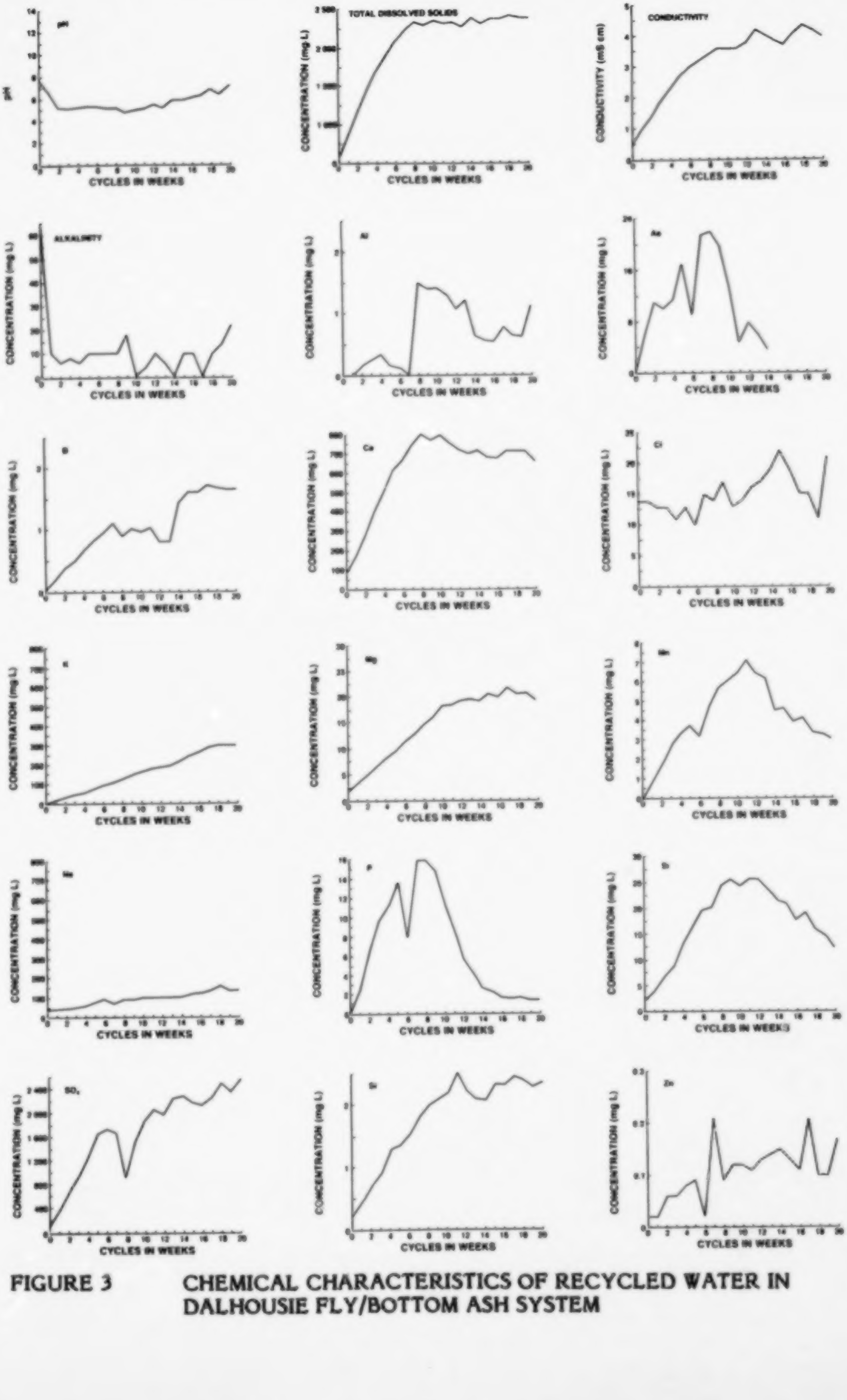


FIGURE 3 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN DALHOUSIE FLY/BOTTOM ASH SYSTEM

TABLE 17 MAXIMUM CONCENTRATIONS REACHED IN SLURRY WATERS

	Eastern Bituminous Coal				U.S. Bituminous Coal				Western Lignite Coal		Western Sub-bituminous Coal			
	Dalhousie		Lingan		Lakeview		Nanticoke		Boundary Dam		Wabamum		Sundance	
Element	Bottom	Fly/Bot.	Bottom	Fly/Bot.	Bottom	Fly/Bot.	Bottom	Fly/Bot.	Bottom	Fly/Bot.	Bottom	Fly/Bot.	Bottom	Fly/Bot.
As	0.050	22.1	0.042	0.438	0.060	0.046	0.113	0.066	0.022	0.022	0.095	0.036	0.014	0.008
Ag	<0.005	0.04	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.006	0.357	0.332	0.223	0.283
Al	2.07	1.51	21.0	193	10.4	12.3	0.64	1.41	1.29	103	0.17	1.77	0.83	5.80
B	0.284	1.72	1.25	16.8	1.79	56.4	1.16	5.72	31.7	32.6	29.1	29.0	9.12	3.84
Ba	0.164	0.084	0.107	0.123	0.078	0.217	0.138	0.581	0.160	0.467	0.155	0.468	0.146	1.10
Ca	572	799	256	611	626	985	307	1 130	277	116	144	652	130	568
Cd	0.02	0.03	0.02	0.33	0.02	0.02	<0.01	0.02	0.02	<0.01	0.20	0.20	0.20	0.20
Cl	25	22	33	35	53	59	81	97	36	39	10	16	23	17
Co	0.19	0.19	0.42	0.60	0.23	0.27	0.27	0.24	0.10	0.11	0.12	0.17	0.11	0.19
Cr	0.04	0.18	0.14	0.30	0.10	0.41	0.10	0.41	0.60	1.24	0.51	2.27	0.35	0.50
Cu	0.998	0.332	0.508	2.26	0.076	0.036	0.041	0.027	0.025	0.065	0.014	0.020	0.012	0.021
Fe	0.13	0.75	1.58	1.58	0.22	0.16	0.13	0.13	0.40	0.16	0.19	0.21	0.33	0.28
K	19	297	65	437	7	190	19	54	25	25	10	22	8	9
Mg	12.5	22.0	29.3	116	28.6	9.27	27.7	0.18	178	3.35	45.6	1.51	25.3	0.83
Mn	1.47	7.13	8.25	10.6	2.54	0.01	0.68	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Mo	0.4	7.4	<0.3	0.5	0.4	4.3	0.6	3.5	0.8	3.2	1.4	3.3	0.5	1.4
Na	94	157	130	417	24	308	66	202	478	1 030	78	237	147	204
Ni	0.11	0.27	1.74	2.40	0.36	0.07	0.13	0.08	0.23	<0.05	0.07	0.13	<0.05	0.17
P	0.7	15.9	<0.6	<0.6	0.6	1.1	<0.6	1.2	1.1	0.8	1.0	2.2	0.9	1.8
Si	6.73	25.3	46.3	68.4	21.9	<0.05	10.5	0.91	3.30	6.48	29.6	19.7	26.5	7.09
Sr	1.02	2.49	<1.75	8.02	3.54	20.6	2.35	31.5	6.02	7.34	0.91	3.92	2.04	12.3
Zn	0.19	0.21	0.88	0.85	1.03	0.56	0.21	0.44	0.27	0.31	0.07	0.10	0.23	0.61
SO_4	1 560	2 580	950	3 110	2 040	2 400	860	1 050	2 170	1 600	490	1 500	520	208

(all results in mg/L)

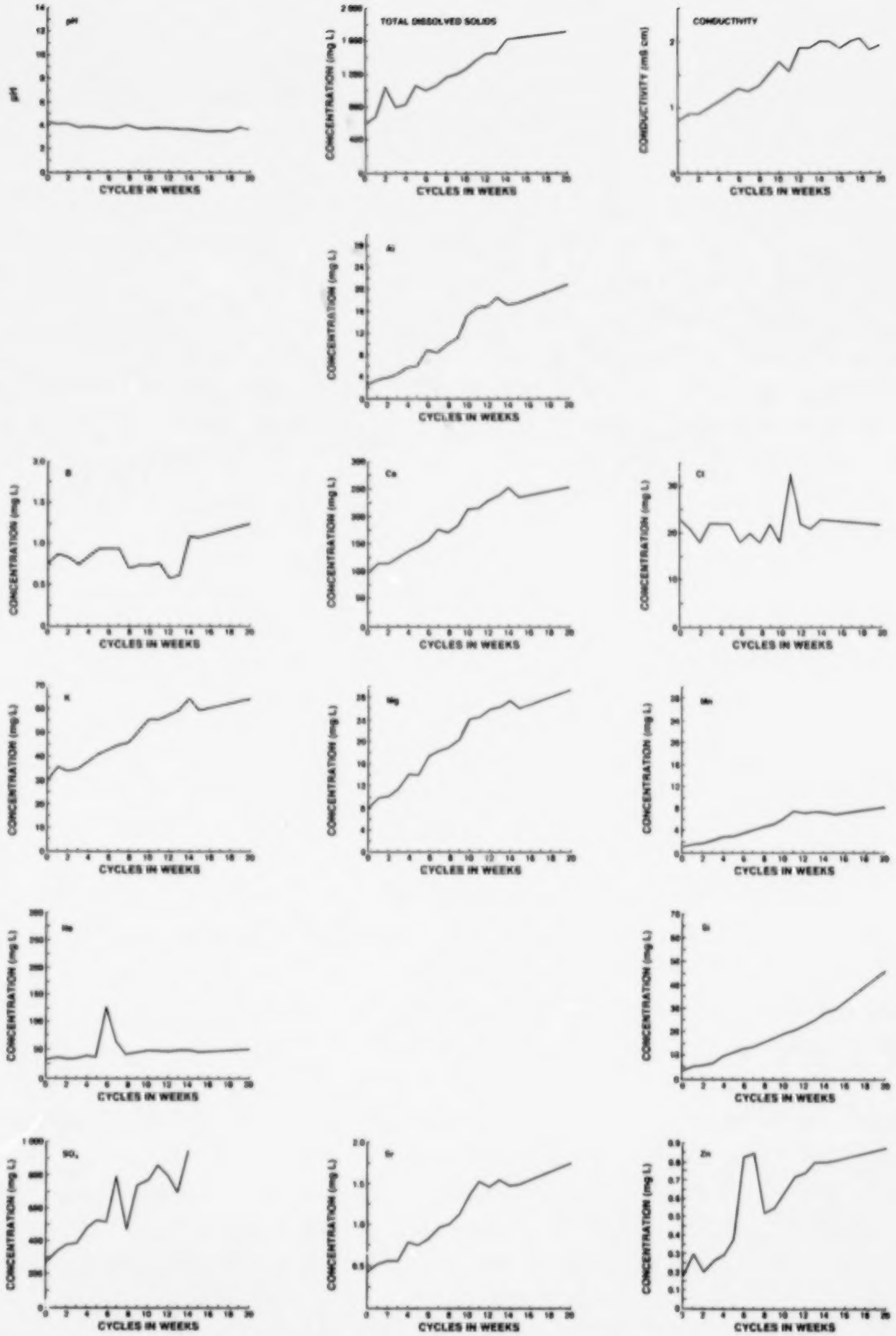


FIGURE 4 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN LINGAN BOTTOM ASH SYSTEM

concentrations increased to Cycle 13 or 14, then decreased. Barium concentrations decreased during the first two cycles then levelled off. The major contributors to total dissolved solids were calcium and sulphate. No scaling was observed during the study.

Slurry water pH in the Lingan fly/bottom ash system fluctuated between 3.9 and 4.4 throughout the 20 cycle study (Figure 5), and was similar to the pH of the Lingan bottom ash slurry water. Unlike the Lingan bottom ash system, however, where many parameters increased during the first part of the study then levelled off, most parameters in the fly/bottom ash system continued to increase throughout the study. Those that increased steadily included cadmium, magnesium, manganese, nickel, potassium, silicon, strontium, thallium and zinc. Boron concentrations increased slowly during the first 13 cycles, then increased more rapidly during the last third of the study. Conductivity and total dissolved solids concentrations increased linearly up to Cycle 13, then continued to increase at a slower rate. Cobalt and sodium concentrations fluctuated but showed an overall increase. The reason for the peaks in sodium concentrations in both Lingan systems is not apparent, but may have been due to analytical errors. Only aluminum, calcium and sulphate concentrations levelled off during the second part of the study, indicating saturation had been achieved for these constituents. Maximum concentrations achieved during the 20 cycles were usually much higher for most parameters in the fly/bottom ash system than in the Lingan bottom ash system (Table 17). Total dissolved solids concentrations were four times higher than those in the Lingan bottom ash system. The major contributors to total dissolved solids were calcium, sulphate, sodium, potassium and aluminum. No scaling was observed during the study.

Lakeview Ash Systems. Slurry water pH in the Lakeview bottom ash system decreased slowly from 8.3 to 7.5 during the first 8 cycles, decreased rapidly to 4.9 during the next three cycles, then decreased slowly to 4.4 at Cycle 20 (Figure 6). Most detectable parameters increased during the study. Conductivity, total dissolved solids and strontium concentrations increased linearly. Aluminum, boron, magnesium, manganese, nickel, silicon and zinc concentrations increased slowly during the first part of the study, then increased more rapidly. The start of these rapid increases corresponds with the rapid decrease in pH during Cycles 9 to 11, which was caused by the depletion of alkalinity in the slurry waters. Iron, potassium and sodium concentrations fluctuated widely, but overall increased slightly during the study. Calcium and sulphate were the largest contributors to total dissolved solids. Calcium concentrations increased linearly during the first 17 cycles then levelled off. Sulphate concentrations increased in steps up to Cycle 12, increased rapidly to peak at Cycle 15, decreased to Cycle 17 then increased

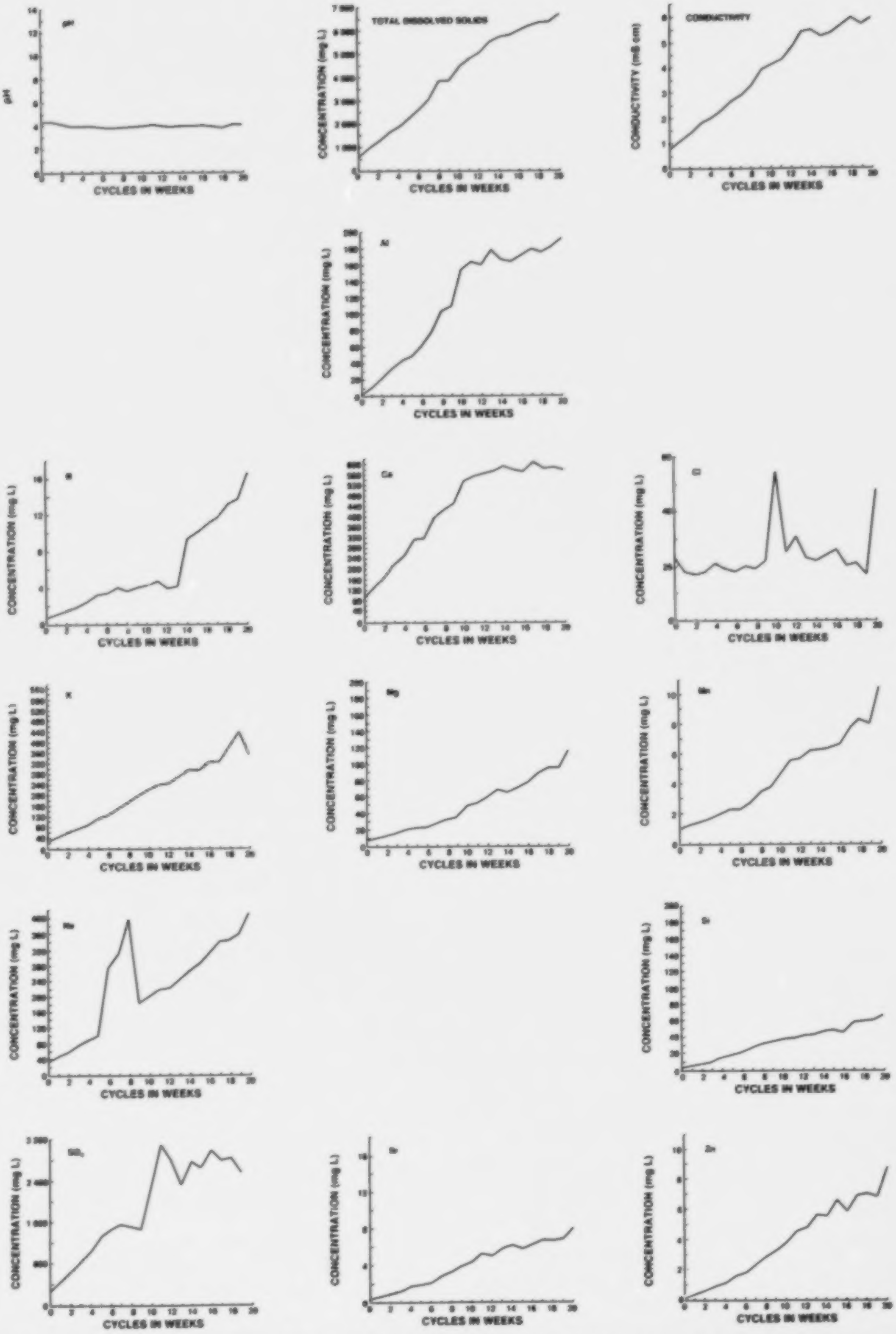


FIGURE 5 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN LINGAN FLY/BOTTOM ASH SYSTEM

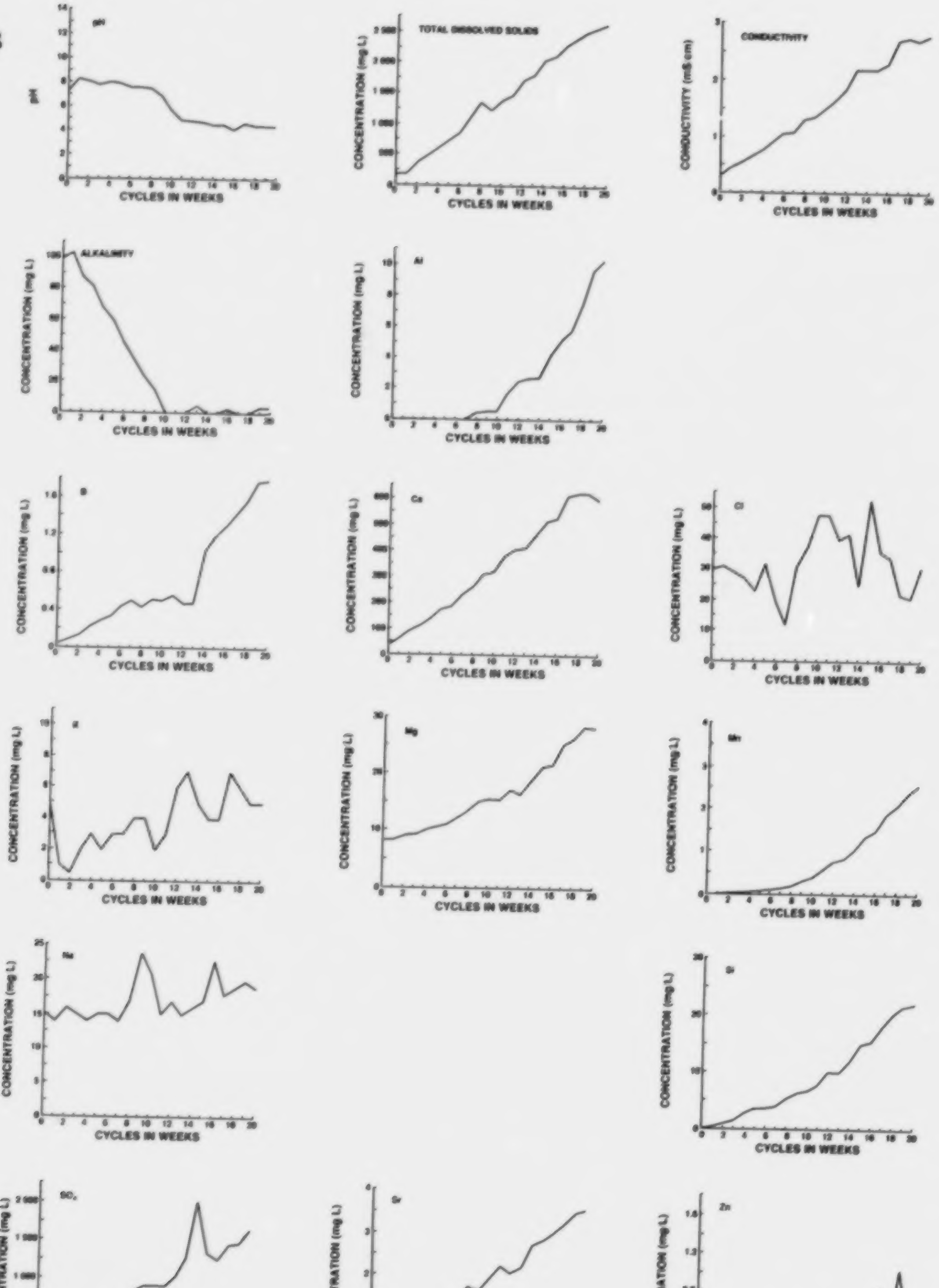


FIGURE 6 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN LAKEVIEW BOTTOM ASH SYSTEM

again. The calcium and sulphate results suggest that solubility limits for these constituents were achieved or exceeded during the latter part of the study. No scaling was observed throughout the 20 cycles.

Slurry water pH in the Lakeview fly/bottom ash system increased during the first cycle from 7.3 in the makeup water to 9.3, increased to 9.9 by Cycle 8, then decreased to 9.1 by Cycle 20 (Figure 7). This pattern is in contrast to that observed in the bottom ash system where pH decreased throughout the study to reach 4.4 at Cycle 20. Maximum concentrations of many elements in this system were higher than those in the bottom ash system (Table 17). Total dissolved solids concentrations in the Lakeview bottom ash system reached 2650 mg/L after 20 cycles, whereas they reached 4860 mg/L in the fly/bottom ash system after only 8 cycles. The general pattern for detectable parameters in the Lakeview fly/bottom ash system was a rapid increase in concentration during the first several cycles, followed by either a levelling off or a decrease. The parameters that decreased after the initial increase were aluminum and calcium. Those that levelled off included alkalinity, conductivity, total dissolved solids, sulphate, and strontium. Sulphate concentrations peaked several times during the study. The general pattern for each peak was a rapid increase to about 2200 mg/L, a constant period of 2 or 3 cycles, then a rapid decrease to about 1300 mg/L. This pattern suggests that sulphate reached or exceeded solubility limits at about 2200 mg/L, which resulted in sulphate precipitation. Molybdenum, potassium, and sodium concentrations increased approximately linearly throughout the 20 cycles. Boron and chlorine concentrations fluctuated widely but generally displayed an increasing trend. Unlike the ash systems previously described, scaling was observed in the Lakeview fly/bottom ash system. The scale was probably calcium sulphate, as indicated by the decrease in calcium concentration after the fifth cycle and the wide fluctuations in sulphate concentration. Calcium, sulphate, potassium and sodium were the major contributors to total dissolved solids.

Nanticoke Ash Systems. Slurry water pH in the Nanticoke bottom ash system decreased slowly during the first 14 cycles from 7.8 to 7.0, then decreased more rapidly to reach 5.2 at Cycle 20 (Figure 8). Most detectable parameters increased during the study. Conductivity, calcium, magnesium, silicon and strontium concentrations increased steadily. Sulphate and total dissolved solids concentrations also increased after an initial decrease. Aluminum and manganese concentrations remained below detection limits during the first 7 to 9 cycles, then increased. Boron concentrations increased slowly during the first 6 cycles, remained constant to Cycle 13, then increased. Iron concentrations fluctuated widely, but overall showed an increasing trend. Only barium

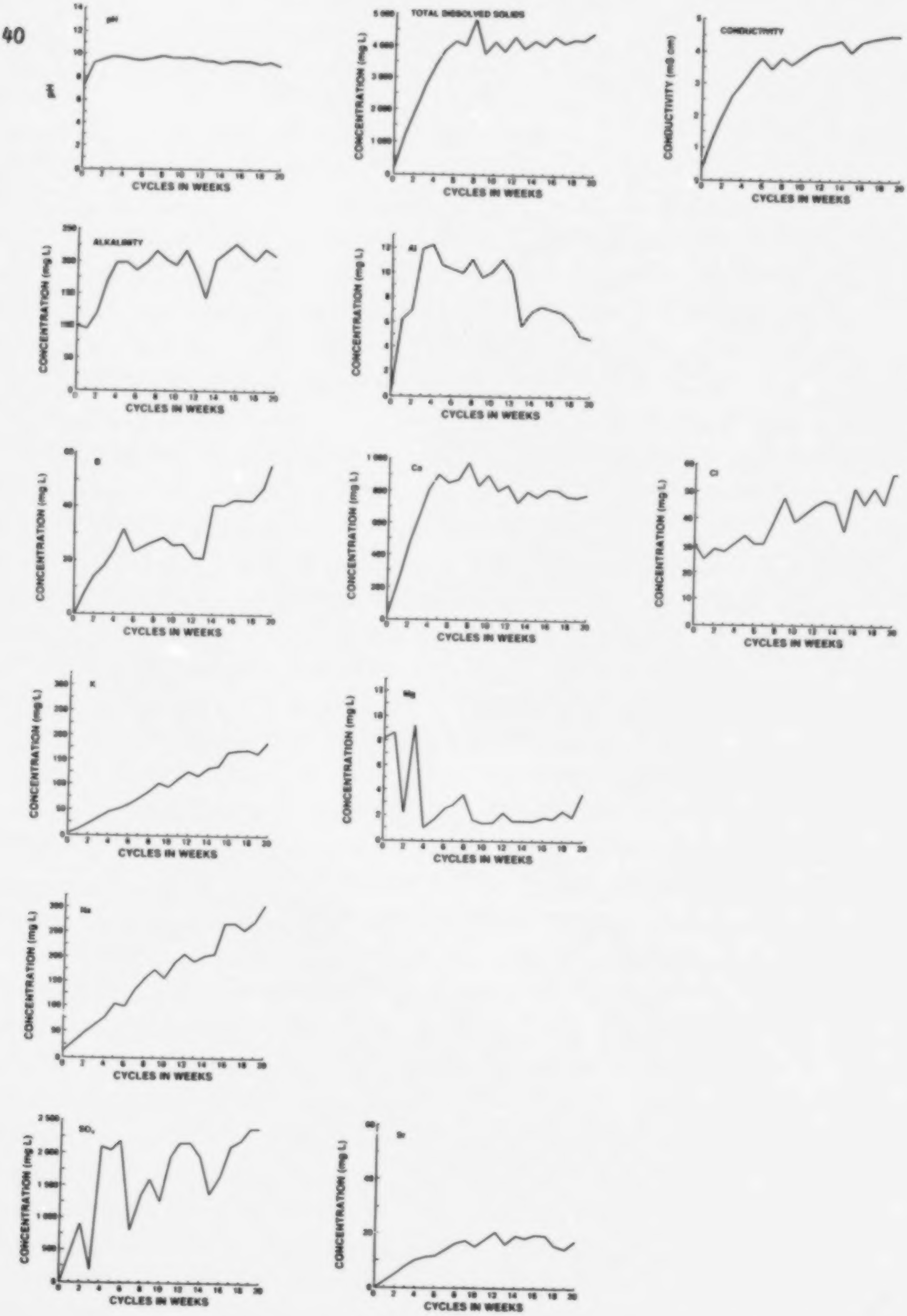


FIGURE 7 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN LAKEVIEW FLY/BOTTOM ASH SYSTEM

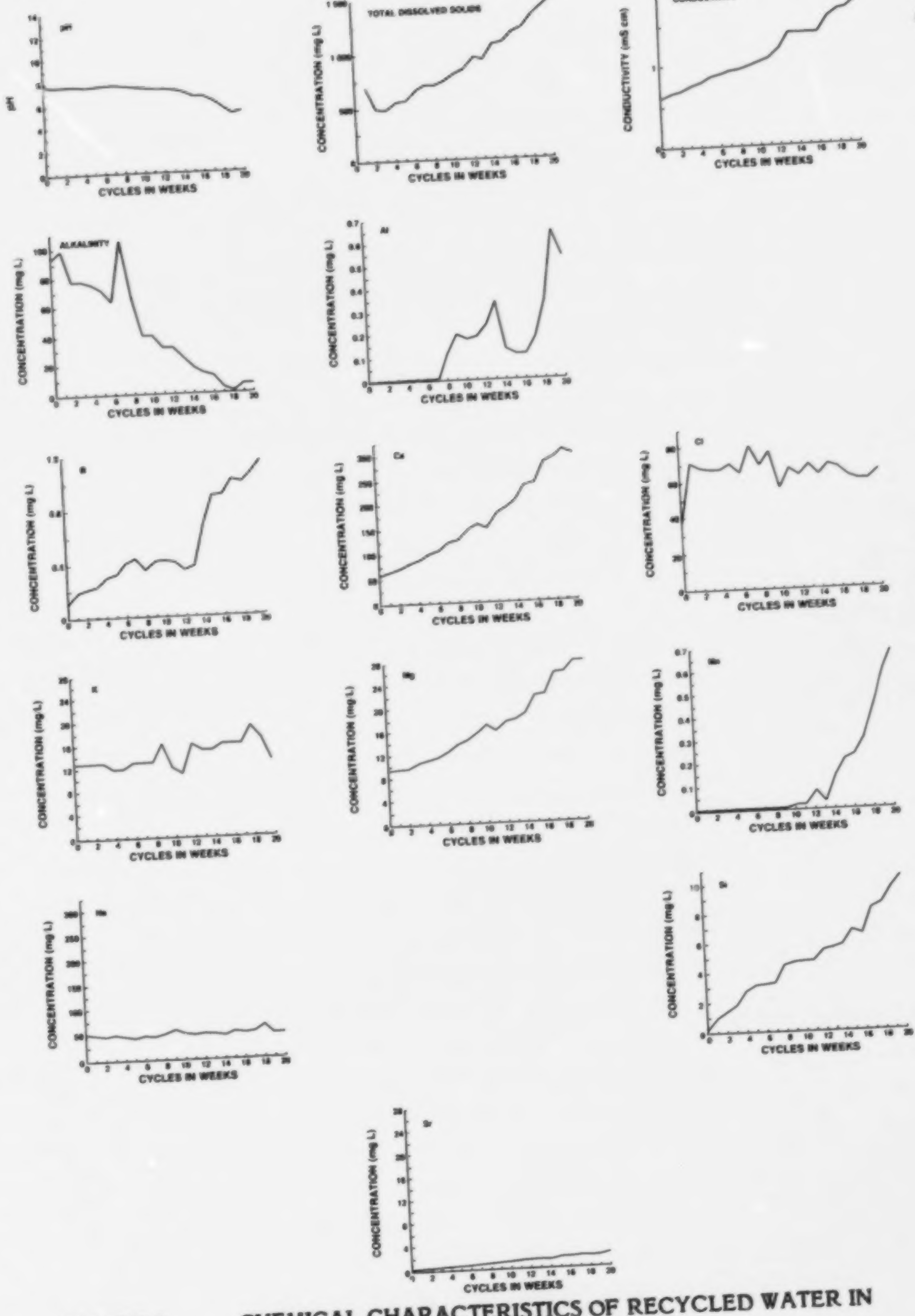


FIGURE 8 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN NANTICOKE BOTTOM ASH SYSTEM

and alkalinity concentrations decreased during the study. Chloride, potassium and sodium concentrations remained relatively constant. No scaling was observed in the system.

Slurry water pH in the Nanticoke fly/bottom ash system increased during the first cycle from 7.8 to 12.1, then fluctuated between 11.9 and 12.4 during the rest of 20 cycle study period (Figure 9). Most detectable parameters increased during the study. Alkalinity, conductivity, boron, calcium, strontium and total dissolved solids concentrations exhibited a common trend of increasing rapidly during the first few cycles, levelling off and remaining constant for the next several cycles, then decreasing. Chlorine, chromium, iron, molybdenum, sodium and sulphate concentrations fluctuated widely but generally showed an increasing trend. The reason for the peaks in the sodium concentrations is not apparent, but may have been due to analytical error. Potassium concentrations increased steadily throughout the study. Barium concentrations, after an initial increase during the first cycle, decreased to Cycle 7 then levelled off. Silicon concentrations peaked at Cycles 1 and 20, but generally remained less than the detection limit of 0.05 mg/L. As noted in the previously discussed ash systems, maximum concentrations were usually higher in the fly/bottom ash system than in the bottom ash system (Table 17). Total dissolved solids in the fly/bottom ash slurry water exceeded 3000 mg/L after 6 cycles, whereas they had only reached 1500 mg/L in the bottom ash slurry water after 20 cycles. Calcium and sulphate ions were the major contributors to total dissolved solids. Scaling was observed on the surface of the slurry water and the sides of the holding tanks after Cycle 8. The occurrence of scaling corresponded to the decreases in alkalinity, calcium and total dissolved solids concentrations after Cycle 8.

Boundary Dam Ash Systems. Slurry water pH in the Boundary Dam bottom ash system fluctuated between 7.7 and 8.7 throughout the study (Figure 10). Most detectable parameters increased during the 30 recirculation cycles. Conductivity, total dissolved solids and sulphate concentrations fluctuated slightly, but overall increased linearly throughout the study. Calcium and sodium concentrations also increased linearly during the first 20 cycles, then levelled off. Magnesium concentrations increased linearly during the first half of the study, then increased more rapidly. Alkalinity, chlorine and chromium concentrations initially decreased during the first few cycles, then increased. Boron and strontium concentrations increased in stages. Cadmium, copper, molybdenum, nickel, phosphorus, potassium and vanadium concentrations fluctuated, but overall increased during the study. Aluminum concentrations increased during the first cycle, decreased to Cycle 8, then increased. Silicon concentrations increased to Cycle 22, then decreased. Barium concentrations decreased rapidly during the first cycle then decreased

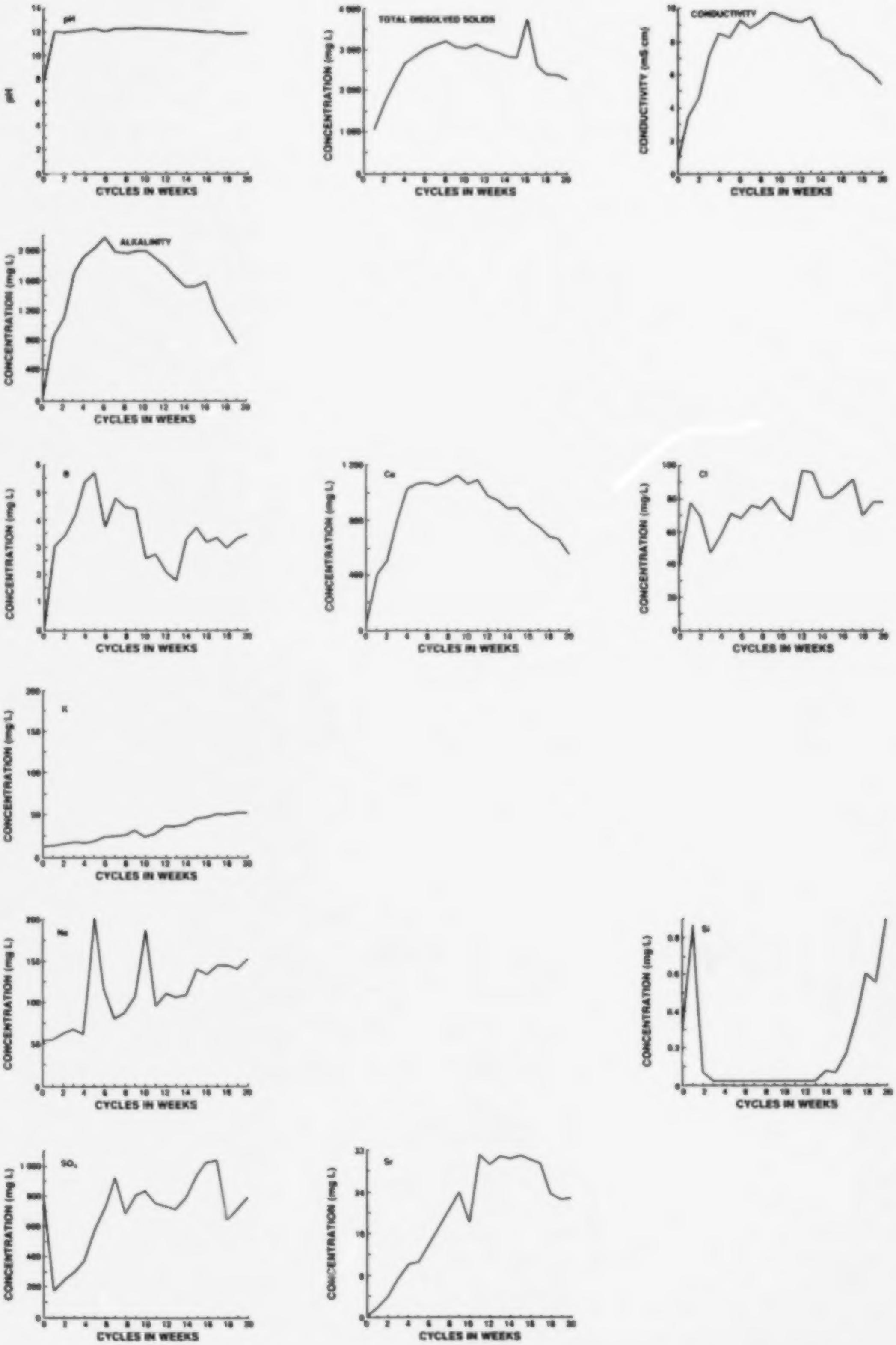


FIGURE 9 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN NANTICOKE FLY/BOTTOM ASH SYSTEM

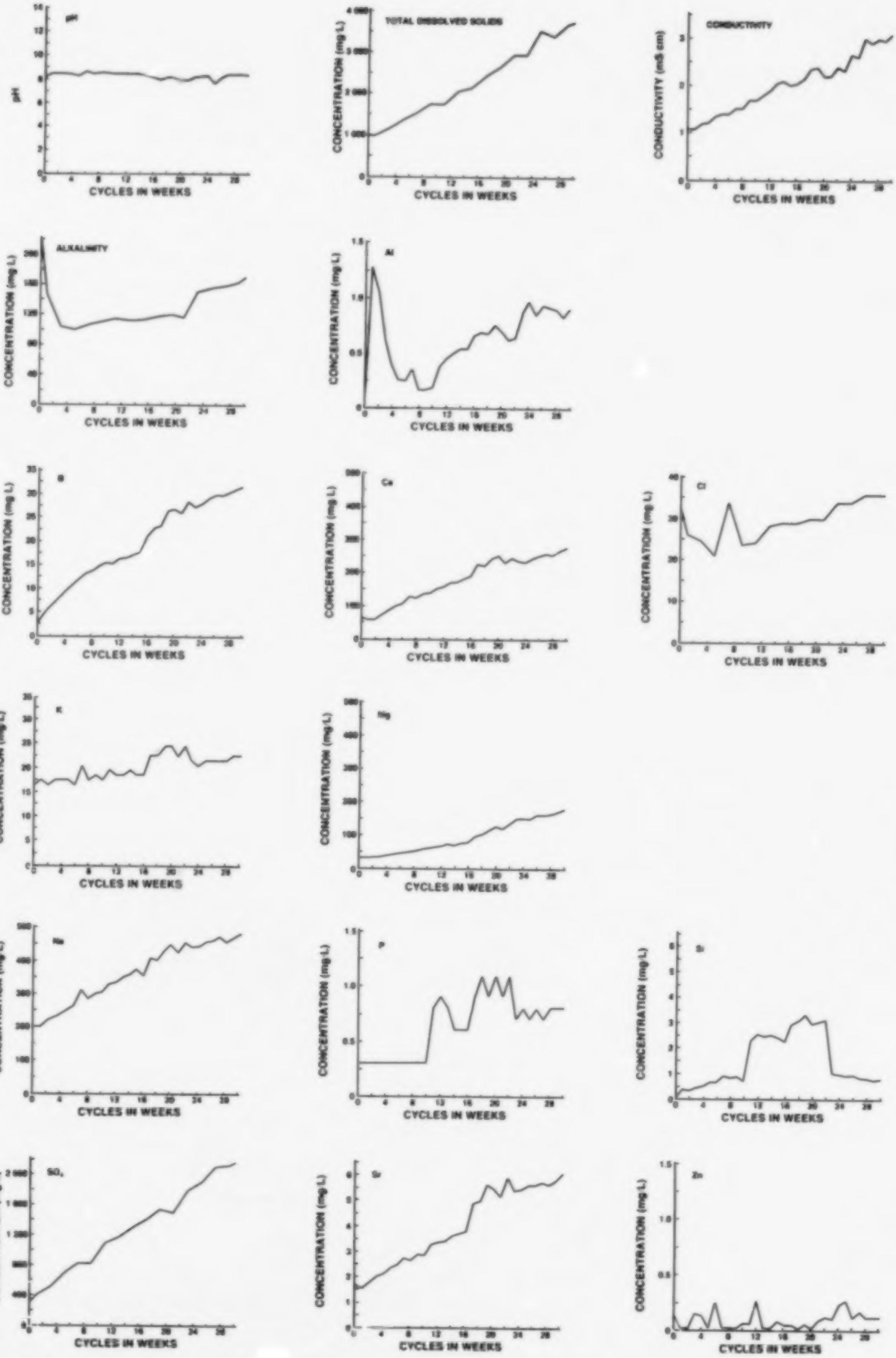


FIGURE 10 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN BOUNDARY DAM BOTTOM ASH SYSTEM

more slowly to Cycle 30. The main contributors to total dissolved solids were sulphate, sodium, calcium and magnesium. No scaling was observed in the system.

Slurry water pH in the Boundary Dam fly/bottom ash system rapidly increased from 8.25 to 11.6 during the first two cycles, slowly increased to 12.1 by Cycle 15, then slowly decreased to reach 11.2 by Cycle 30 (Figure 11). Most detectable parameters increased during the study. Boron, chromium, vanadium and total dissolved solids concentrations increased steadily. Conductivity, aluminum, molybdenum and sodium concentrations increased steadily during the first part of the study, then levelled off. Alkalinity, potassium, silicon and sulphate concentrations increased during the first 22 to 24 cycles, then decreased. Calcium and strontium concentrations also increased to a peak and then decreased; however, the peak occurred much earlier in the study. Barium, chloride, iron, phosphorus and zinc concentrations fluctuated widely during the 30 recirculation cycles. In general, phosphorus concentrations increased, barium concentrations decreased, and chloride, iron and zinc concentrations remained constant. Magnesium concentrations decreased rapidly during the first two cycles, then generally remained less than 1 mg/L for the balance of the study. The major contributors to total dissolved solids were sulphate and sodium. Scaling was observed on the sides of the mixing tank after Cycle 7.

Wabamum Ash Systems. Slurry water pH in the Wabamum bottom ash system remained at about 8.2 throughout the 29 recirculation cycles (Figure 12). Conductivity, boron, calcium, chloride, magnesium, molybdenum, silicon, sodium, strontium, sulphate, vanadium and total dissolved solids concentrations increased during the study. Potassium concentrations remained fairly constant. Alkalinity concentrations decreased. Iron and phosphorus concentrations fluctuated widely, but remained below 0.2 and 1.0 mg/L, respectively. Cadmium and silver concentrations decreased after the first few cycles to below or near their detection limits. Barium concentrations increased during the first cycle, decreased steadily to Cycle 10, then increased steadily during the balance of the study. Aluminum concentrations peaked near the beginning and end of the study, but generally were less than the detection limit. The major contributors to total dissolved solids were sulphate, calcium and sodium. No scaling was observed in the system.

Slurry water pH in the Wabamum fly/bottom ash system increased from 8.5 to 10.6 during the first cycle, then fluctuated between 10.5 and 11.5 during the rest of the 29 cycle study (Figure 13). The prevalent trend for many of the detectable parameters in this system was an exponential increase in concentration throughout the study. The parameters exhibiting this trend were boron, calcium, potassium, sulphate, strontium,

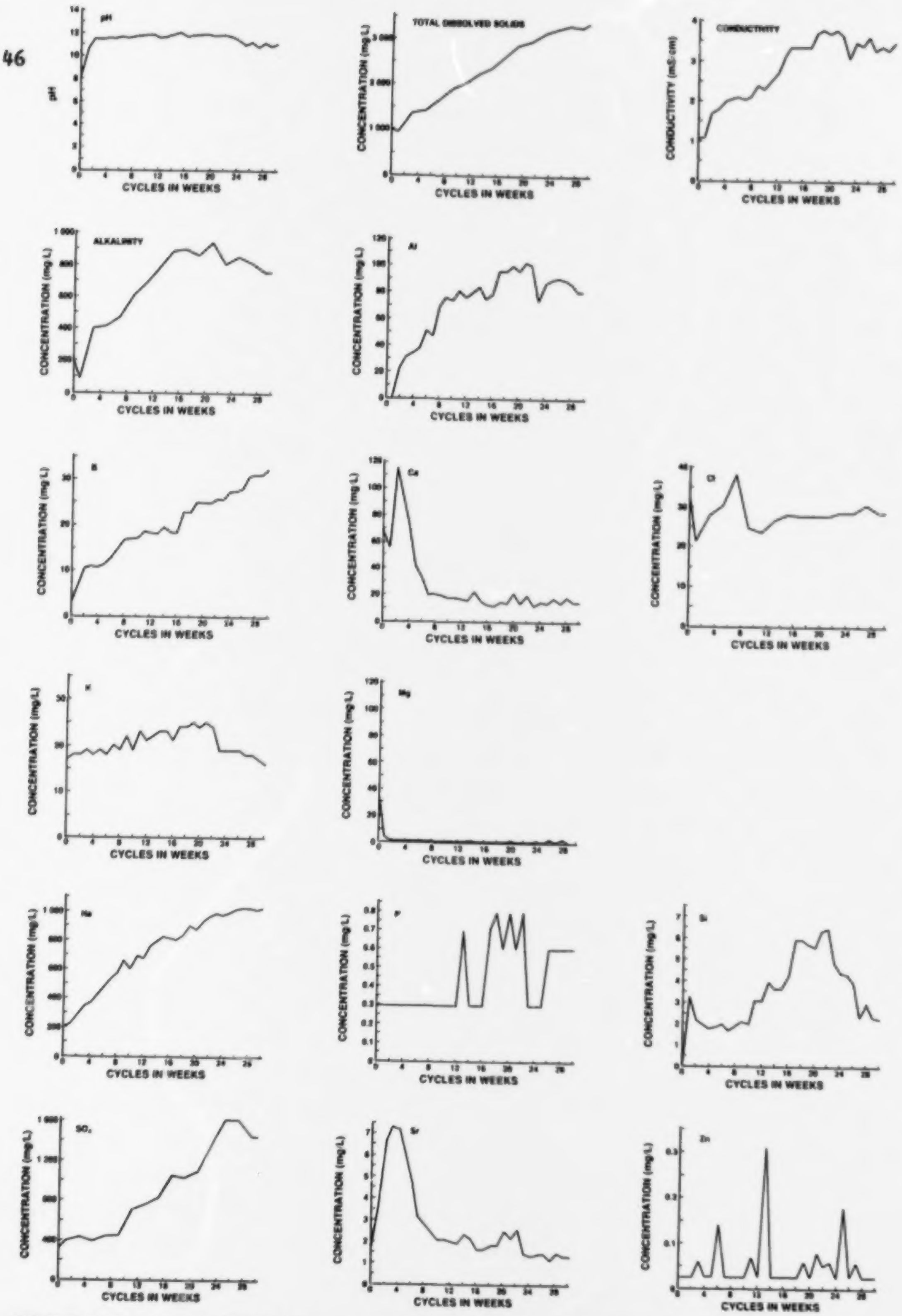


FIGURE 11 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN BOUNDARY DAM FLY/BOTTOM ASH SYSTEM

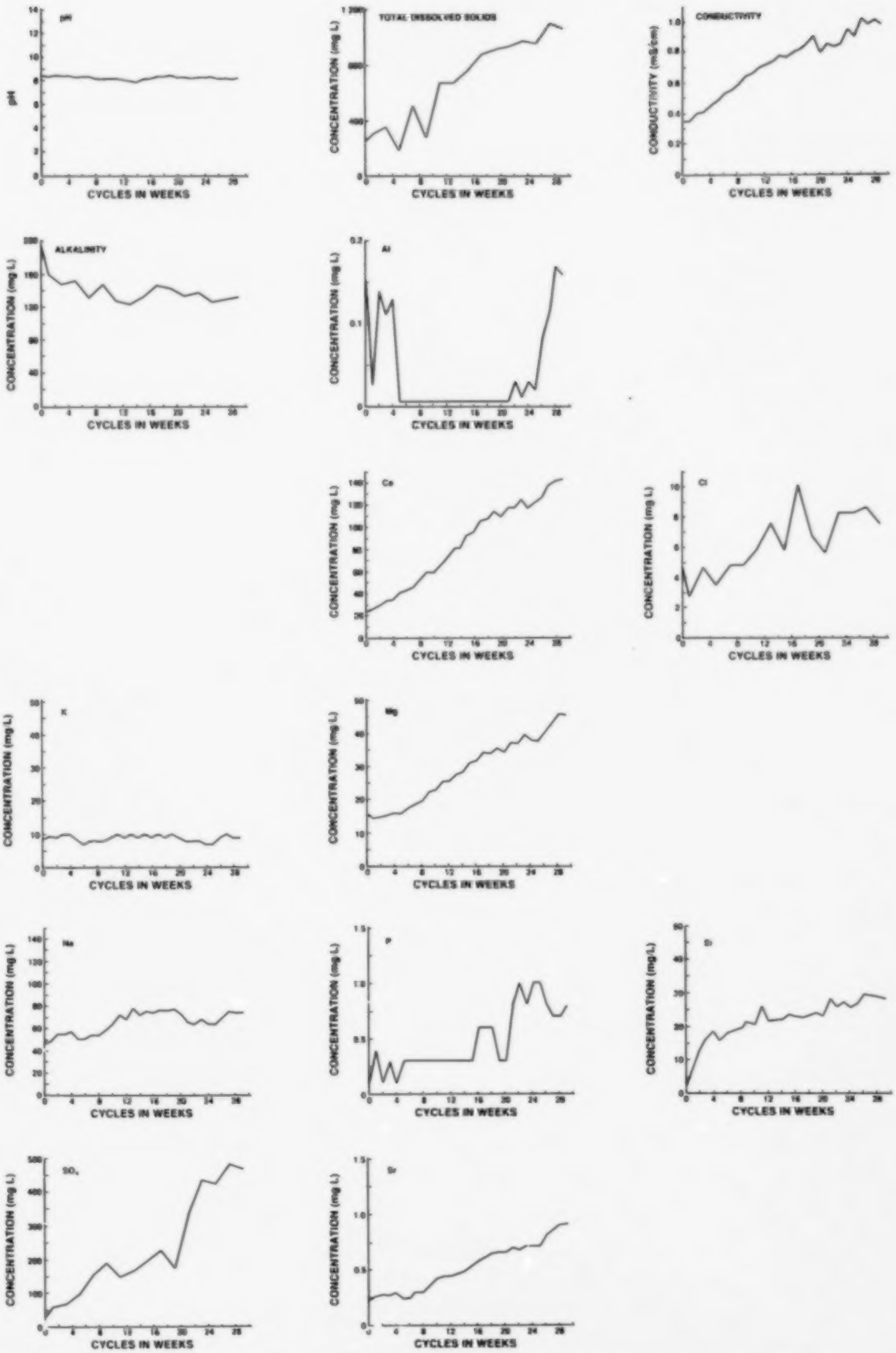


FIGURE 12 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN WABAMUM BOTTOM ASH SYSTEM

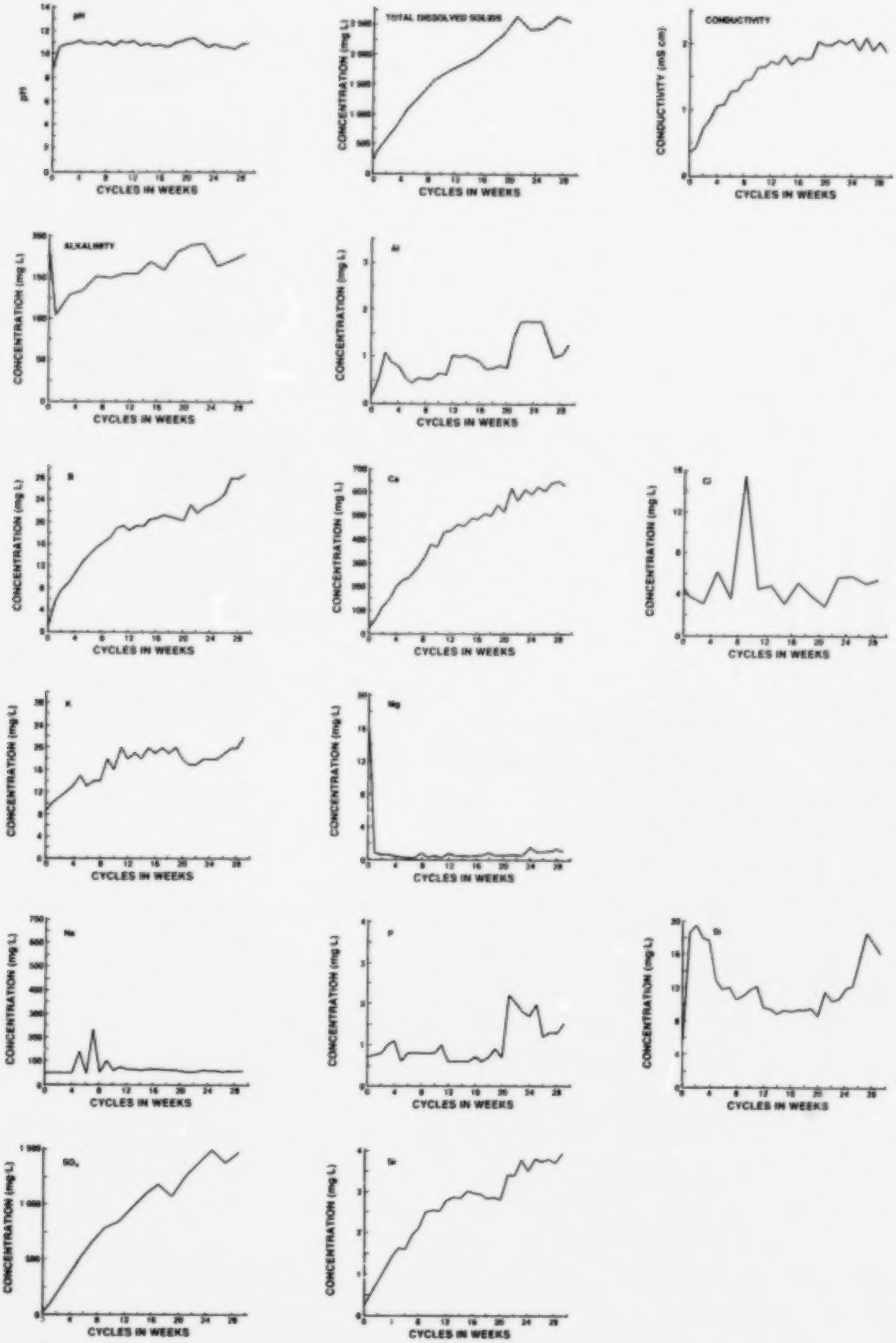


FIGURE 13 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN WABAMUM FLY/BOTTOM ASH SYSTEM

conductivity and total dissolved solids. Alkalinity also increased exponentially after an initial decrease at Cycle 1. Chromium and molybdenum concentrations increased steadily throughout the study. Aluminum, iron, nickel and phosphorus concentrations fluctuated widely but generally displayed an increasing trend. Sodium and chlorine concentrations also fluctuated but overall remained constant. Silicon and vanadium concentrations peaked after 2 to 4 cycles, decreased to Cycle 12, remained constant to Cycle 20, then increased. The major contributors to total dissolved solids were calcium and sulphate. Scaling was observed on the sides of the mixing tank during and after Cycle 8.

Sundance Ash Systems. Slurry water pH in the Sundance bottom ash system decreased during the first cycle from 8.7 to 8.3, then remained constant for the rest of the 30 cycle study period (Figure 14). Most detectable parameters in this system increased during the first part of the study then either continued to increase at a much slower rate or levelled off. These parameters included boron, calcium, silicon, sodium, vanadium, conductivity and total dissolved solids. Sulphate concentrations fluctuated widely, but generally increased up to Cycle 9, decreased to Cycle 19, then increased to peak at Cycle 27. Strontium concentrations increased linearly. The parameters that decreased during the study included alkalinity, barium, magnesium, potassium and silver. Chloride concentrations fluctuated widely but overall remained constant. The major contributors to total dissolved solids were sulphate, sodium and calcium. No scaling was observed in the system.

Slurry water pH in the Sundance fly/bottom ash system increased during the first 3 cycles from 8.7 to 12.0, then remained between 11.8 and 12.2 for the balance of the 30 cycle study period (Figure 15). The general trend exhibited by most parameters in this system was a rapid increase during the first several cycles to a peak, followed by a decrease. The parameters that followed this trend were alkalinity, barium, calcium, conductivity, iron, potassium, silver, strontium, sulphate and total dissolved solids. Aluminum, chromium and sodium concentrations fluctuated but overall increased during the study. Boron concentrations remained constant to Cycle 8, decreased steadily to Cycle 23, then increased. Silicon concentrations increased during the first cycle, decreased rapidly during the next 3 cycles, then increased. Chloride concentrations fluctuated but overall remained constant. Phosphorus concentrations decreased. The major contributors to total dissolved solids were calcium, sulphate and sodium. Scaling was observed on the surface of the slurry water and the sides of the mixing tank during Cycle 5 and subsequent cycles.

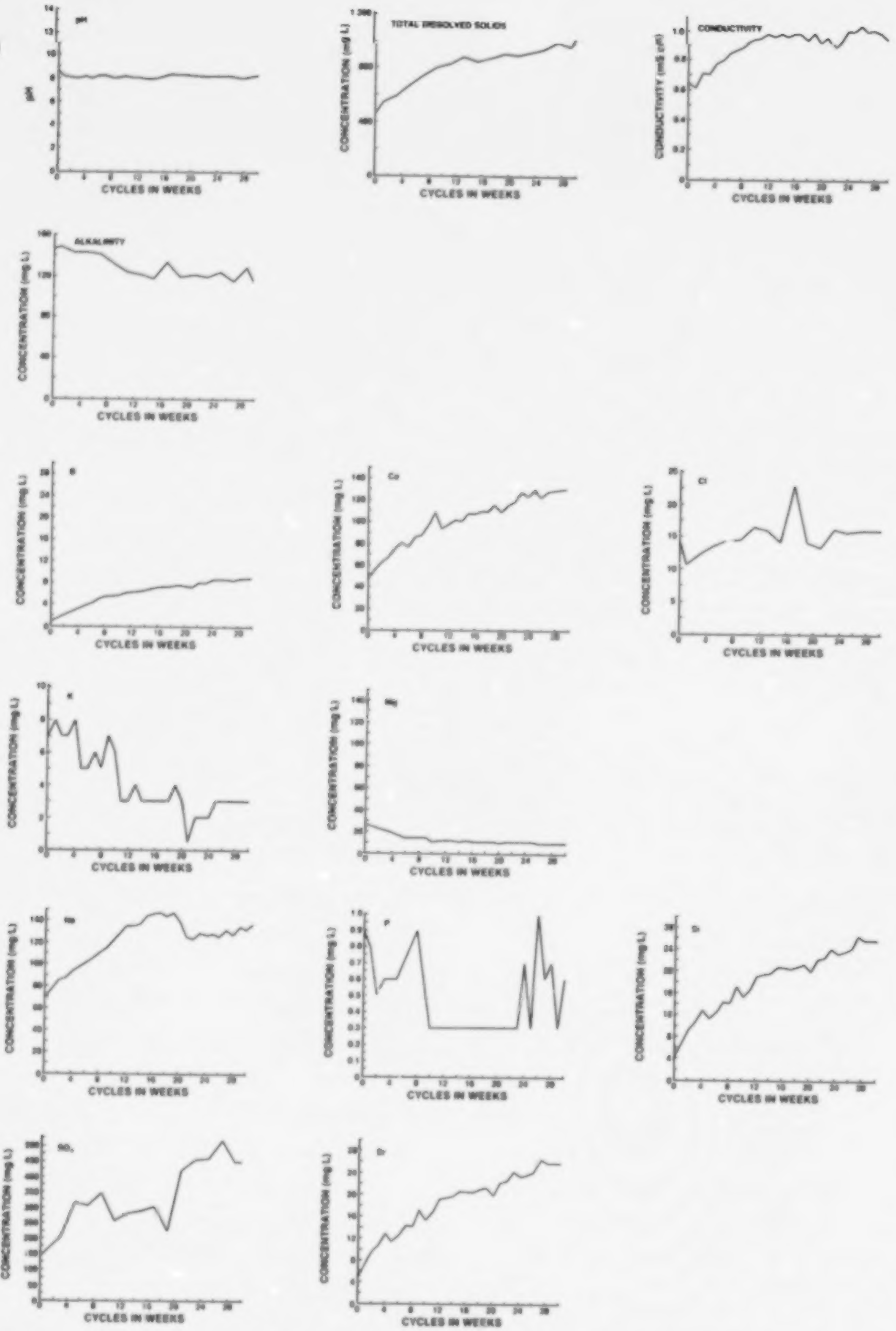


FIGURE 14 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN SUNDANCE BOTTOM ASH SYSTEM

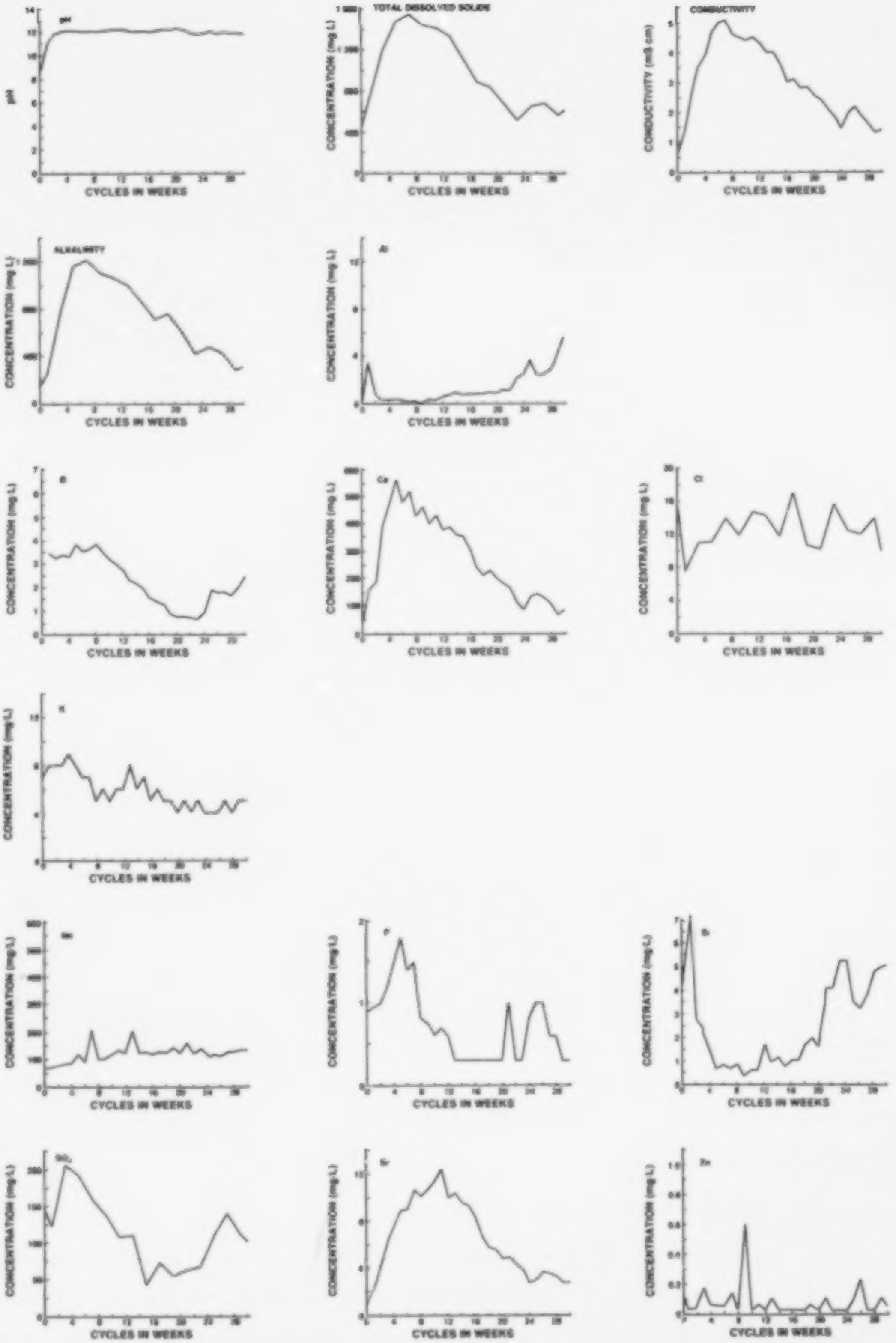


FIGURE 15 CHEMICAL CHARACTERISTICS OF RECYCLED WATER IN SUNDANCE FLY/BOTTOM ASH SYSTEM

3.4.3 Radiochemical Analyses of Slurry Waters. Results of the radiochemical analyses of slurry waters after the final cycle are given in Table 18. As expected from the generally low radionuclide levels in the ashes (Table 16) most parameters were less than or near detection limits, with the exceptions of dissolved gross α in the Dalhousie and Wabamum systems, and dissolved gross β in almost all systems.

3.4.4 Priority Pollutant Analyses of Slurry Waters. Results of the base/neutral and acid-extractable priority pollutant analyses of slurry waters after the final cycle are given in Table 19. No compounds were detected in the acid group, and three phthalates were detected in the base/neutral group. However, these phthalates may not be related to ash leaching since the studies were conducted in polyethylene tanks.

3.5 Serial Batch Leaching Tests

A serial batch leaching test was performed on a mixture of 75% fly ash and 25% bottom ash from the Lakeview Plant in order to compare the results to those obtained from the ash recirculation study. The protocol was similar to that used in the WTC Multiple-Batch Leaching Procedure (Côté and Constable, 1982). The ash was leached for 20 cycles using the Lakeview mix water at a 20:1 (liquid:solid) ratio. Each 24-h cycle consisted of 22 hours of mixing by slow rotation in a square polypropylene bottle, a 15 to 30 minute settling period, decantation of the slurry water, and addition of fresh ash to the decant. The pH and conductivity of the slurry water were measured after every cycle. After Cycles 1, 5, 10, 15 and 20, a 50 mL aliquot of slurry water was collected, filtered through 0.45 µm filter paper, and submitted for ICP analysis.

The results of the batch leaching test and the recirculation test are compared in Table 20. In general, the agreement of elemental concentrations in the slurry waters from the two tests was very good. Concentrations were usually at least of the same order of magnitude in the two waters, and often were remarkably similar (e.g., Ca, K, Mo, Na, P and Sr). There were only a few elements, such as aluminum and magnesium, that had markedly different concentrations in the two waters at equal cycles. This suggests that, in future studies of this type, serial batch leaching tests should be used instead of the more time-consuming and complex simulated ash lagoons employed in this program.

3.6 Mathematical Modelling of Slurry Water

In order to assist in data interpretation and to examine if the observed slurry water quality could be predicted using a mathematical model, the results of the Lingan, Dalhousie, Nanticoke and Lakeview ash recirculation studies were examined using a model

TABLE 18 RADIOCHEMICAL ANALYSES OF SLURRY WATERS FROM LAST CYCLE*

Ash System	Suspended pCi/L (Bq/L)		Dissolved pCi/L (Bq/L)											
	Gross α	Gross β	Gross α		Gross β		^{226}Ra		^{210}Pb		^{232}Th	^{230}Th	^{228}Th	
Dalhousie Bottom Ash	<1	<1	10	(0.37)	106	(3.92)	<1		< 1		<1	<1	<1	
Dalhousie Fly/Bottom Ash	<1	<1	<1		372	(13.76)	<1		4	(0.15)	<1	<1	<1	
Lingan Bottom Ash	<1	<1	<1		2	(0.074)	<1		5	(0.19)	<1	<1	<1	
Lingan Fly/Bottom Ash	<1	<1	<1		59	(2.18)	<1		5	(0.19)	<1	<1	<1	
Lakeview Bottom Ash	<1	<1	<1		< 1		<1		5	(0.19)	<1	<1	<1	
Lakeview Fly/Bottom Ash	<1	<1	<1		320	(11.84)	<1		4	(0.15)	<1	<1	<1	
Nanticoke Bottom Ash	<1	<1	<1		2	(0.074)	<1		2	(0.074)	<1	<1	<1	
Nanticoke Fly/Bottom Ash	<1	<1	<1		214	(7.92)	<1		5	(0.19)	<1	<1	<1	
Boundary Dam Bottom Ash	NA	NA	<1		9	(0.33)	<1		5	(0.19)	<1	<1	<1	
Boundary Dam Fly/Bottom Ash	NA	NA	<1		2	(0.074)	<1		5	(0.19)	<1	<1	2	(0.074)
Wabamum Bottom Ash	NA	NA	17	(0.63)	< 1		4	(0.15)	<15	(<0.56)	<1	<1	<1	
Wabamum Fly/Bottom Ash	NA	NA	7	(0.26)	12	(0.44)	<1		<15	(<0.56)	<1	<1	<1	
Sundance Bottom Ash	NA	NA	<1		44	(1.63)	1	(0.037)	<15	(<0.56)	<1	<1	2	(0.074)
Sundance Fly/Bottom Ash	NA	NA	4	(0.15)	37	(1.37)	1	(0.037)	<15	(<0.56)	<1	<1	<1	

* 20 cycles for Dalhousie, Lingan, Lakeview and Nanticoke systems;
29 cycles for Wabamum systems; 30 cycles for Boundary Dam and Sundance systems

NA = not analyzed

Notes: <1 is <0.037 Bq/L

TABLE 19 GC/MS ORGANIC ANALYSES OF SLURRY WATERS FROM LAST CYCLE*

Ash System	Compound** (mg/L) butylbenzyl phthalate	di-n-butyl phthalate	bis(2-ethylhexyl) phthalate
Dalhousie Bottom Ash	0.02	<0.01	0.01
Lingan Bottom Ash	<0.01	0.08	<0.01
Lakeview Bottom Ash	<0.01	0.13	<0.01
Nanticoke Fly/Bottom Ash	0.03	<0.01	0.04
Boundary Dam Bottom Ash	<0.01	0.11	<0.01
Boundary Dam Fly/ Bottom Ash	<0.01	0.09	<0.01
Wabamum Bottom Ash	<0.01	0.13	<0.01
Wabamum Fly/Bottom Ash	<0.01	0.17	<0.01
Sundance Bottom Ash	<0.01	0.02	<0.01
Sundance Fly/Bottom Ash	<0.01	0.06	<0.01

* 20 cycles for Dalhousie, Lingan, Lakeview and Nanticoke systems; 29 cycles for Wabamum systems; 30 cycles for Boundary Dam and Sundance systems

** no other compounds in the acid and base/neutral groups were detected

developed by Montreal Engineering. This model had previously been used to interpret and accurately predict the behaviour of ashes in contact with water for a number of bench-scale and full-scale once-through and recirculating ash disposal systems. It is based on the concept that the quality of water in contact with ash is largely controlled by the dissolution of the readily soluble components in the ash (primarily the oxides and sulphates of calcium, sodium and potassium) which in turn governs the dissolution of the relatively insoluble components of the ash and those elements present in trace amounts.

The model requires solubility data for the components in the ashes, water and component material balances for all readily soluble components, and the stoichiometric, electroneutrality and equilibrium relationships which apply to the system. The solubilities of the fly and bottom ashes were estimated based on the quality of the make-up waters and of the slurry waters from Cycle 1, and are given in Table 21 (Montreal Engineering,

TABLE 20 COMPARISON BETWEEN SLURRY WATER CHARACTERISTICS FOR ASH RECIRCULATION TEST AND SERIAL BATCH LEACHING TEST, WITH LAKEVIEW FLY/BOTTOM ASH

	Cycle 1		Cycle 5		Cycle 10		Cycle 15		Cycle 20	
Parameter	Recirc.	Batch	Recirc.	Batch	Recirc.	Batch	Recirc.	Batch	Recirc.	Batch
pH	9.30	10.95	9.60	10.80	9.75	10.70	9.50	10.60	9.10	10.50
Conductivity	1.25	1.25	3.45	2.98	3.85	3.58	4.00	3.82	4.50	4.10
Ag	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Al	6.22	25.2	10.60	6.28	10.10	9.60	7.28	15.2	4.74	25.4
B	7.89	8.22	31.9	20.4	25.9	31.1	40.8	35.7	56.4	39.3
Ba	0.217	0.295	0.116	0.060	0.083	0.014	0.080	0.187	0.112	0.096
Be	< 0.000 5	< 0.000 5	< 0.000 5	< 0.000 5	< 0.000 5	< 0.000 5	< 0.000 5	< 0.000 5	< 0.000 5	< 0.000 5
Ca	241	281	908	673	908	837	773	788	790	773
Cd	< 0.01	0.03	< 0.01	0.04	< 0.01	0.06	0.01	0.06	0.02	0.06
Co	< 0.05	< 0.05	< 0.05	0.07	0.06	0.13	0.14	0.07	< 0.05	< 0.05
Cr	0.05	0.14	0.15	0.52	0.20	0.65	0.30	0.85	0.41	0.60
Cu	< 0.008	0.009	< 0.008	0.016	< 0.008	0.024	0.016	0.016	0.016	0.016
Fe	0.02	0.15	0.08	0.24	0.09	0.23	0.11	0.20	0.13	0.12
K	13	12	53	55	98	103	140	141	190	182
Mg	8.74	0.11	1.66	0.38	1.41	0.44	1.60	0.50	3.81	0.43
Mn	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mo	0.3	0.4	1.2	1.4	1.9	2.5	2.9	3.2	4.3	4.2
Na	31	36	107	106	159	174	208	231	308	303
Ni	< 0.05	0.11	< 0.05	0.14	< 0.05	0.14	0.07	0.20	0.07	0.18
P	< 0.6	< 0.6	0.6	0.6	1.0	0.8	0.8	1.2	0.9	1.3
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Si	< 0.05	< 0.05	< 0.05	0.75	< 0.05	0.43	< 0.05	0.14	< 0.05	< 0.05
Sr	3.03	3.94	11.5	14.2	15.6	19.4	18.6	20.7	17.3	21.0
Th	0.11	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.07	< 0.01
Ti	< 0.005	< 0.005	< 0.005	< 0.005	0.009	0.006	0.007	0.005	< 0.005	0.005
V	0.116	0.101	0.130	0.142	0.131	0.140	0.151	0.112	0.127	0.095
Zn	< 0.05	0.12	< 0.05	0.21	< 0.05	0.10	< 0.05	0.07	< 0.05	0.16
Zr	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

all results reported in mg/L, except for pH (units) and conductivity (mS/cm)

TABLE 21 ESTIMATED SOLUBILITY OF ASHES (Montreal Engineering, 1982)

	Lingan		Dalhousie		Nanticoke		Lakeview	
	Bottom Ash	Fly Ash	Bottom Ash	Fly Ash	Bottom Ash	Fly Ash	Bottom Ash	Fly Ash
pH*	4.2	4.4	7.8	6.6	7.7	12.1	8.8	9.3
Aluminum	14.2	209	~0	~0	~0	~0	~0	158
Boron	1.70	10.8	0.424	4.10	1.43	74.2	0.911	199
Calcium	287	887	332	2160	103	8710	400	4980
Chloride	~0	~0	~0	~0	~0	741	~0	~0
Magnesium	32.3	51.9	5.83	33.6	2.71	~0	2.14	12.2
Potassium	108	367	17.7	399	~0	25.3	~0	228
Silicon	25.7	53.3	7.06	45.6	13.2	10.1	8.39	~0
Sodium	71.8	304	35.3	114	~0	36.8	~0	412
Strontium	1.60	6.23	0.230	5.36	1.21	42.0	2.32	71.9
Sulphate	1076	4180	883	6520	~0	~0	589	11 700

* pH of slurry water during Cycle 1
all units in mg/kg ash except pH

1982). They must be considered as very approximate as a relatively high solid-to-liquid ratio and mineralized water was used to generated the leaching data. These factors can cause the precipitation of relatively insoluble components such as calcium carbonate and gypsum. Removal of solutes from solution by precipitation was not taken into account in estimating the solubilities. These estimates can be considered to be most reliable for those constituents that form very soluble components such as sodium and potassium.

The major constituents dissolved from the ashes were calcium, sodium, potassium and sulphate. The minor constituents were aluminum, boron, magnesium, silicon and strontium. In general, the model was able to predict closely the observed trends in these constituents over the 20 leaching cycles, except in some cases where the model was unable to predict decreases in calcium and/or sulphate concentrations which were due to the precipitation of gypsum and/or calcium carbonate. Predictions for minor constituent concentrations were also poorer in the systems where precipitation occurred. This may have been due to the "coating" of the ash particles by the precipitates, thereby limiting the exposure of the particles to the liquid phase.

3.7 Quality Assurance Testing

Duplicate ash analyses were performed by Barringer on ash samples sent to them in two separate batches, using Inductively Coupled Plasma (ICP). A third replicate ash sample was analyzed at the WTC laboratory by Direct Current Argon Plasma or Atomic Absorption. Reproducibility within replicated Barringer analyses was very good for most parameters. The largest variations were in analyses of cadmium, sodium and phosphorus. In general, the WTC laboratory results were not significantly different from the Barringer laboratory results, with the exceptions of Be, Cd, Na, Sr, Ti and V. These exceptions were probably due to the use of different digestion media in the two laboratories (hydrofluoric acid dissolution in the Barringer laboratory versus aqua-regia digestion in the WTC laboratory).

For liquid samples, reproducibility within replicated Barringer analyses was very good. However, WTC results were significantly different from the Barringer results for many of the parameters (e.g., aluminum, barium, silicon and strontium). The reasons for these large differences are not apparent, although they may have been partly due to the different analytical techniques used by the two laboratories (Table 6).

4 SUMMARY AND DISCUSSION

4.1 Experimental Procedure

Bench-scale studies were conducted to simulate the operation of recirculating ash lagoons. Ash mixing and settling operations were performed in 68-L polyethylene tanks. Fresh ash was added to slurry water at a ratio of 1 part ash to 19 parts water. The ash slurry was then mixed vigorously for 10 minutes and allowed to stand for 7 days. The supernatant was then decanted, sampled and contacted with fresh ash. This procedure was carried out for 20 or 30 cycles.

A much simpler serial batch leaching procedure involving 24-h leaching cycles was also conducted on one of the ash mixtures. Each cycle consisted of 22 hours of mixing of ash and slurry water in a 1-L polypropylene bottle, a 15 to 30 minute settling period, decantation of the supernatant, and addition of fresh ash to the decant.

The results of the serial batch leaching test agreed with those of the simulated ash lagoon test. Elemental concentrations in slurry waters from the same cycles in the two systems were usually at least of the same order of magnitude, and often were remarkably similar. It is recommended that future studies of this type be conducted using the serial batch leaching procedure instead of the more time consuming and complex simulated ash lagoon system.

The good agreement between observed slurry water quality and predictions based on mathematical modelling of the ash system supports the theory that slurry water quality is controlled by the dissolution of the readily soluble components of ash (oxides and sulphates of calcium, sodium and potassium) and that this governs the dissolution of other components of ash. However, the utility of the mathematical model was limited by its inability to accurately predict dissolved component concentrations in systems where precipitation occurred. Thus, the model could not be considered a substitute for laboratory studies such as the simulated ash lagoon or serial batch leaching tests described in this report.

4.2 Ash Characteristics

The ranges of concentrations in the seven sets of bottom and fly ashes are summarized in Table 22. The concentrations were generally within the ranges cited in the literature (Table 1); however, several parameters exceeded the maximum concentrations reported in Table 1. These included barium, cadmium, iron and potassium in bottom ashes, and manganese, sodium, phosphorus and silicon in both bottom and fly ashes.

TABLE 22 CONCENTRATION RANGES IN BOTTOM AND FLY ASHES

Element	Concentration (µg/g)		
	Bottom Ash		Fly Ash
Ag	< 0.5		<0.5
Al	66 800 - 130 000		76 200 - 131 000
B	10 - 626		33 - 973
Ba	161 - 10 800		478 - 11 100
Be	4.1 - 8.5		6.0 - 10.5
Ca	4 660 - 121 000		5 650 - 131 000
Cd	2.8 - 5.5		1.8 - 5.1
Co	< 5 - 17		< 5 - 25
Cr	5.4 - 92		18 - 124
Cu	32 - 116		42 - 162
Fe	19 900 - 313 000		20 100 - 298 000
K	3 630 - 29 800		2 730 - 29 400
Mg	3 310 - 21 600		3 440 - 26 100
Mn	122 - 1 840		187 - 1 670
Mo	<30		< 30 - 46
Na	1 590 - 36 700		1 770 - 42 600
Ni	16 - 91		20 - 109
P	520 - 4 580		710 - 6 180
Pb	< 5 - 28		24 - 325
Si	180 000 - 367 000		176 000 - 338 000
Sr	250 - 1 830		266 - 1 980
Th	< 1 - 29		< 1 - 30
Ti	2 840 - 6 160		3 520 - 6 480
U	0.5 - 18.5		4.0 - 17.5
V	51 - 170		64 - 224
Zn	18 - 119		25 - 601
Zr	179 - 281		153 - 365

Silver, thorium and uranium concentrations were lower in some fly ashes than the minimum reported in Table 1. The major elements in the ashes were Al, Ba, Ca, Fe, K, Mg, Na, P, Si and Ti.

4.3 Slurry Water pH

For most ash systems, the slurry water pH reached a near steady state value within the first two cycles of recirculation. Values for pH ranged between 3.5 and 12.5 in the 14 ash systems that were studied, and were generally lower in a bottom ash system than in the corresponding fly/bottom ash system.

Slurry waters from Western Canada lignite and Western Canada sub-bituminous coal ashes (Boundary Dam, Wabamum and Sundance) were consistently basic throughout the study, with pHs ranging between 7.7 and 8.7 in the bottom ash systems and between 10.5 and 12.3 in the fly/bottom ash systems. Slurry water pHs for Eastern Canada bituminous coal ashes (Dalhousie and Lingan) were not as consistent, with bottom ash system pHs ranging from 7.1 to 7.8 for Dalhousie compared to 3.5 to 4.2 for Lingan, and fly/bottom ash system pHs ranging from 4.8 to 7.2 for Dalhousie versus 3.9 to 4.4 for Lingan. The pH of slurry waters for U.S. bituminous coal ashes (Lakeview) ranged between 4.1 and 8.3 in the bottom ash system and between 9.1 and 9.9 in the fly/bottom ash system. The pH of slurry waters for ashes from a mixture of U.S. and Western Canada bituminous coals (Nanticoke) ranged between 5.0 and 7.7 in the bottom ash system and between 11.9 and 12.4 in the fly/bottom ash system.

Generally, relationships between slurry water pH and maximum elemental concentrations were not well defined. This may have been due to the dominant effect of ash morphology on leachability. For some parameters, however, high concentrations were associated with low pH while low concentrations were associated with high pH. This trend was noted for aluminum and manganese in the bottom ash systems and for Cu, Fe, K, Mg, Mn, Ni and Si in the fly/bottom ash systems.

4.4 Maximum Concentrations

The maximum parameter concentrations reached in the slurry waters during the 20 to 30 recirculation cycles are shown in Table 23. The major disolved species in the slurry waters (i.e., those shown in Figures 2 to 15) were sulphate, calcium, sodium, potassium, aluminum, magnesium, chloride, silicon, boron, strontium, arsenic, phosphorus, manganese, and zinc. The maximum concentrations for these species ranged from 8.85 mg/L (zinc) to 3110 mg/L (sulphate). Other major parameters were conductivity, alkalinity and total dissolved solids. Elements which had maximum concentrations greater

TABLE 23 MAXIMUM CONCENTRATIONS REACHED IN RECIRCULATED SLURRY WATERS

Analyte	Maximum Concentrations Reached*	
	Bottom Ash Systems	Fly/Bottom Ash Systems
Ag	< 0.005 - 0.357	< 0.005 - 0.332
Al	0.17 - 21.0	1.41 - 193
As	0.014 - 0.113	0.007 - 22.1
B	0.284 - 31.7	1.72 - 56.4
Ba	0.078 - 0.164	0.084 - 1.10
Be	< 0.000 5 - 0.003 0	< 0.000 5 - 0.046 2
Ca	130 - 626	116 - 1130
Cd	< 0.01 - 0.20	< 0.01 - 0.33
Cl	10.2 - 81	15.5 - 97
Co	0.10 - 0.42	0.11 - 0.60
Cr	0.04 - 0.60	0.18 - 2.27
Cu	0.012 - 0.998	0.020 - 2.26
Fe	0.13 - 1.58	0.13 - 1.58
Hg (µg/L)	0.2 - 1.3	0.2 - 0.6
K	7 - 65	9 - 437
Mg	12.5 - 178	0.18 - 116
Mn	< 0.01 - 8.25	< 0.01 - 10.6
Mo	< 0.2 - 1.4	0.5 - 7.4
Na	24 - 478	157 - 1030
Ni	0.05 - 1.74	< 0.05 - 2.40
P	< 0.6 - 1.1	< 0.6 - 15.9
Pb	< 0.05 - 0.15	< 0.05 - 0.05
Sb	< 0.003 - 0.008	< 0.005 - 0.080
Se	0.014 - 0.044	0.018 - 0.975
Si	3.30 - 46.3	< 0.05 - 68.4
SO_4	490 - 2170	208 - 3110
Sr	0.913 - 6.02	2.49 - 31.5
Th	0.04 - 0.18	0.05 - 0.27
Ti	< 0.005 - 0.033	0.008 - 0.040
Tl	< 0.003 - 0.039	< 0.003 - 2.07
U (µg/L)	1.0 - 23.0	< 0.2 - 9.0
V	0.029 - 0.081	0.042 - 0.230
Zn	0.07 - 1.03	0.10 - 8.85
Zr	< 0.05 - 0.05	< 0.05 - 0.20
Cond. (mS/cm)	1.03 - 3.09	2.12 - 9.75
Alkalinity	< 1 - 170	< 1 - 2190
TDS	1020 - 3760	1560 - 6720

* mg/L unless otherwise noted

than 1 mg/L in at least one ash system but were not considered major dissolved species were molybdenum, nickel, chromium, copper and thallium. As shown in Table 23 the maximum concentrations generally occurred in the fly/bottom ash systems.

This can probably be attributed to ash morphology. The elements in fly ash are more readily leached than those in bottom ash because fly ash particles have a much larger surface area to volume ratio and because elements on the surface of fly ash particles are more available for leaching than those fixed in the matrices of bottom ash.

The maximum concentrations are generally two to three orders of magnitude larger than those reported in the literature for once-through systems (Table 2), but are similar to those reported for the 20-cycle recirculation study conducted by Chu et al. (1978).

4.5 Changes in Parameter Concentrations with Increasing Cycles of Concentration

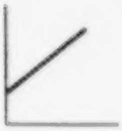
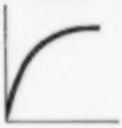
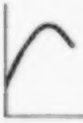
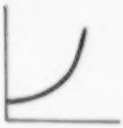
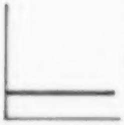
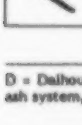
Changes in parameter concentrations with increasing cycles of recirculation displayed wide variability among different parameters and among the same parameters in different ash systems. To assist in data interpretation, six general trends were identified:

1) a linear increase in concentration with increasing cycles of recirculation;
2) a rapid increase in concentration during the first several cycles followed by either a much slower rate of increase or a period of approximately constant concentration;
3) a steady increase in concentration during the first several cycles to a peak followed by a steady decrease in concentration during the latter part of the study;
4) a slow increase in concentration during the first several cycles followed by a relatively rapid increase in concentration during the balance of the cycles;
5) approximately constant concentration throughout the study; and
6) a decrease in concentration with increasing cycles of recirculation.

The major parameter plots in Figures 2 to 15 were classified into these trends by visual inspection (Table 24). In some cases, it was difficult to categorize an observed trend; the closest trend was selected and is indicated in Table 24 with a question mark.

The percent of the major parameters following each trend is shown in Figure 16. The concentrations of most of the major parameters increased either during the first several cycles or throughout the study, and thus followed one of the first four trends. The major trend followed by parameters in bottom ash systems was the first one, indicating that many of the parameters in the bottom ash systems had not achieved their solubility limits by the end of the study. The major trends for the fly/bottom ash systems

TABLE 24 GENERAL TRENDS FOR MAJOR PARAMETERS

Trend	Station Name/ Ash System	TDS	Cond.	Alk.	Al	As	B	Ca	Cl	K	Mg	Mn	Na	P	Si	SO_4	Sr	Zn
1. Linear increase	D/B	x	x				x	x	?	x	x		x		x	x	x	
	D/FB																	
	Li/B												?			?		
	Li/FB									x	x	x	?		x		x	x
	La/B	x	x					x								?	x	
	La/FB								?	x			x					
	N/B	x	x					x			x				x	x	x	
	N/FB									x			?					
	BD/B	x	x													x		
	BD/FB	x					x											
	W/B	x	x				x	x			x						x	
	W/FB																	
	S/B																x	
	S/FB																	
2. Rapid increase then slower or constant	D/B																	
	D/FB	x	x				x			x	x		x			x	x	x
	Li/B	x	x		x			x		x	x	x					x	x
	Li/FB	x	x		x			x								x		
	La/B									?								
	La/FB	x	x	x										x		?	x	
	N/B																	
	N/FB								?					?		x		
	BD/B					x	x	x	?				x	?			x	
	BD/FB		x		x	?							x	?				
	W/B					?			?				?		x			
	W/FB	x	x	x	?		?	x		x						?	x	
	S/B	x	x				x	x					x		x			
	S/FB												?				x	
3. Increase to a peak then decrease	D/B				x	x												
	D/FB				x	x		x	?			x		x	x			
	Li/B					x												
	Li/FB					x			?									
	La/B					x			?									
	La/FB				x	x		x										
	N/B					x				?								
	N/FB	x	x	x	?	x	x	x									x	
	BD/B				?					?					x			
	BD/FB			x				x		x					x	x	x	
	W/B																	
	W/FB								?				?		?			
	S/B								?									
	S/FB	x	x	x			?	x	?	x				x		x	x	
4. Slow increase then more rapid	D/B											x						
	D/FB																	
	Li/B						?								?			
	Li/FB						x					x						
	La/B				x		x				x	x	?		x			x
	La/FB						x											
	N/B				x		x					x						
	N/FB														?			
	BD/B			?							x							
	BD/FB																	
	W/B				?													
	W/FB					?								?				
	S/B				x													
	S/FB				?										x			
5. Constant	D/B													x				?
	D/FB			?														
	Li/B			x					?					x				
	Li/FB			x										x				
	La/B													x				
	La/FB											x			x			?
	N/B								?				x	x				x
	N/FB											x						?
	BD/B																	?
	BD/FB											x						?
	W/B									x				?				x
	W/FB											x						x
	S/B					x						x		x				x
	S/FB					x						x						x
6 Decrease	D/B			x														
	D/FB																	
	Li/B																	
	Li/FB																	
	La/B			x														
	La/FB										x							
	N/B			x														
	N/FB										x							
	BD/B											x						
	BD/FB								?		x							
	W/B			x								x						
	W/FB										x							
	S/B			x						x	x							
	S/FB										x							

D = Dalhousie, Li = Lingan, La = Lakeview, N = Nanticoke, BD = Boundary Dam, W = Wabamun, S = Sundance; B = bottom ash system, FB = fly/bottom ash system

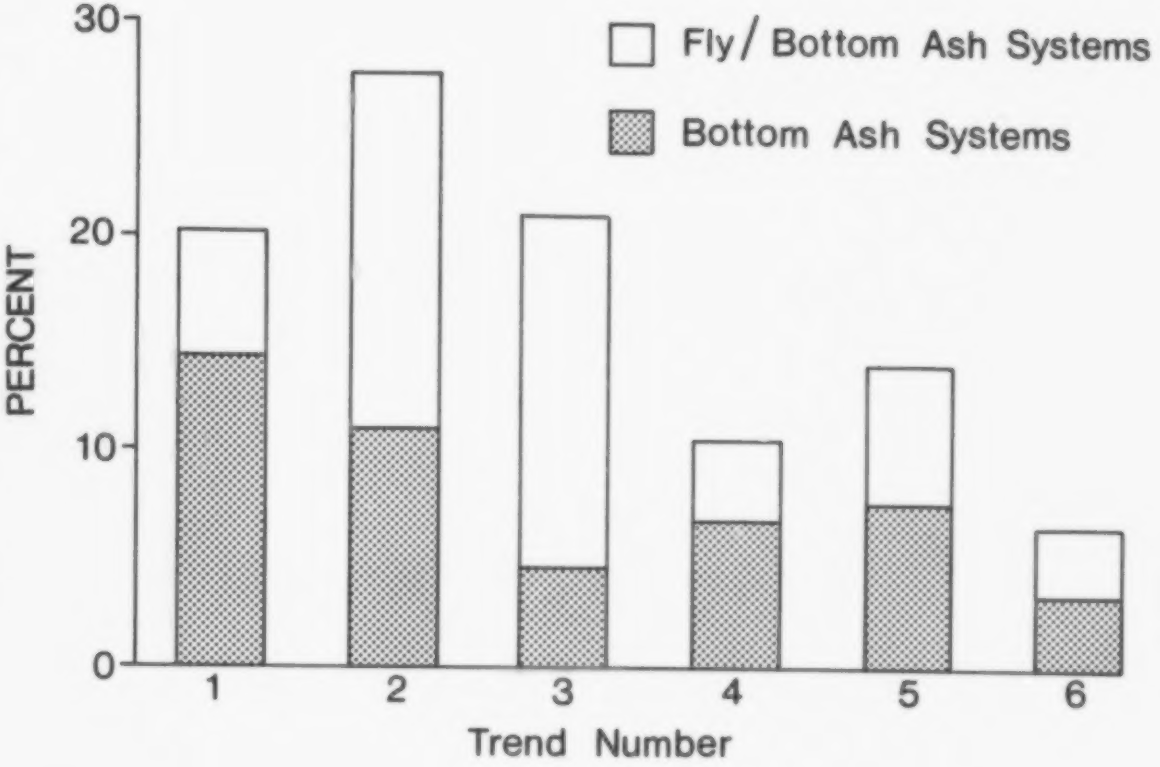


FIGURE 16 PERCENT OF MAJOR PARAMETERS FOLLOWING EACH TREND

were 2 and 3, indicating that concentrations in these systems, were often solubility limited.

Of the remaining elements not shown in Table 24, Be, Cd, Hg, Pb, Sb, Ti and Zr generally remained below or near detection limits throughout the 20 or 30 cycles, Ag remained below detection limits or decreased, Co, Cr, Mo, Ni and Se remained below detection limits or increased, Ba remained constant or decreased, Cu, Fe, Th and Tl remained constant or increased, and U both increased and decreased.

4.6 Scaling

Scaling was observed only in studies involving fly/bottom ash from stations burning Western Canada coal or a mixture of Western Canada and U.S. bituminous coal. Scaling was not observed in any of the bottom ash studies or in any studies involving ash from Eastern Canada coal. Scaling occurred in all studies in which the pH was 9.1 or greater but did not occur when the pH was less than 9.1. It must be noted that these studies were conducted at room temperature, and that much higher temperatures are experienced in the field. Most types of scale are formed preferentially on the hottest surface in the water system since the solubility of most scale-forming minerals decreases with increasing temperature.

5 ENVIRONMENTAL IMPLICATIONS OF RECIRCULATING VERSUS ONCE-THROUGH ASH SLUICING

In this study the concentrations of most parameters were found to increase substantially with increasing cycles of recirculation. Such behaviour in full-scale systems will increase the possibility that recirculating ash slurry water released as blowdown or a spill will be acutely toxic to aquatic life and/or will exceed discharge criteria.

A comparison between maximum concentrations and pH ranges in the slurry waters to recommended effluent criteria contained in the Environmental Codes of Practice for Steam Electric Power Generation (Environment Canada, 1985) is shown in Table 25. The acceptable pH range of 6.5 to 9.5 was exceeded during at least some of the recirculation cycles in all ash systems. Recommended effluent criteria were exceeded for iron in the Lingan system, for chromium in the Boundary Dam and Wabamum systems, for copper in the Dalhousie and Lingan systems, for nickel in the Lingan system, and for zinc in the Lingan, Lakeview and Sundance systems.

TABLE 25 COMPARISON OF MAXIMUM PARAMETER CONCENTRATIONS IN RECIRCULATING ASH SYSTEMS TO RECOMMENDED EFFLUENT CRITERIA

	R211*	Dalhousie	Lingan	Lakeview	Nanticoke	Boundary Dam	Wabamum	Sundance
pH	6.5-9.5	4.8-7.8	3.5-4.4	4.1-9.9	5.0-12.4	7.7-12.1	7.9-11.5	8.0-12.3
Fe	≤1.0	0.75	1.58	0.22	0.13	0.40	0.21	0.33
Cr	≤0.5	0.18	0.30	0.41	0.41	1.24	2.27	0.50
Cu	≤0.5	1.0	2.26	0.076	0.041	0.065	0.020	0.021
Ni	≤0.5	0.27	2.40	0.36	0.13	0.23	0.13	0.17
Zn	≤0.5	0.21	8.85	1.03	0.44	0.31	0.10	0.61

* Recommendation R211 of the Environmental Codes of Practice for Steam Electric Power Generation (Environment Canada, 1985)
all results reported in mg/L except pH (units)

In this study the concentrations of highly soluble elements such as calcium and magnesium increased linearly with increasing cycles of recirculation, indicating that approximately the same elemental mass was transferred in each cycle from the ash to the water. This implies that on a cumulative basis, the total mass discharge of such elements from a once-through system and from a recirculating system with blowdown will be similar. For elements for which solubility limits were reached, however, the rate of increase in concentration decreased with increasing cycles of recirculation. This implies that the total mass discharge of these elements from a recirculating system with blowdown will be less than from a once-through system.

In full-scale systems the magnitude by which mass discharges are reduced by recirculation of the ash transport water will vary depending on the degree of recirculation, the elements considered, ash characteristics, and blowdown rates. The results of this study indicate that the greatest reductions in mass discharges are likely to be achieved in recirculating fly ash systems because solubility limits are achieved for more parameters in the fly/bottom ash systems than in the bottom ash systems. However, the wide variations in parameter behaviour among the studied ash systems indicate that the effect of recirculation on full-scale ash systems will have to be evaluated on a case by case basis.

The reduced volume of wastewater discharges from recirculating ash systems and the higher concentrations of contaminants would make treatment of these wastewaters more efficient than treatment of once-through ash system wastewaters.

The scaling observed in some systems would impose a constraint on the degree of recirculation possible without treatment. The systems where this constraint would be most severe would be recirculating fly ash systems at stations burning Western Canada coal. A study of such systems concluded that they would in fact have a tendency to scale (Behie et al., 1982). Although the same study evaluated methods for reducing scaling potential, such as acid addition, the feasibility of scale prevention procedures and the effect of acid addition on the solubility of other compounds has not been adequately documented.

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APPENDIX

PARAMETER CONCENTRATION
IN
SLURRY WATERS

BOUNDARY DAM FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr
0	<0.005	<0.01	0.006	2.76	0.311	<0.0005	68.4	<0.01	32.5	<0.05	0.62	<0.008	0.10	<0.1	17	32.2	<0.01	<0.3	199	<0.05	<0.6	<0.05	<0.005	<0.005	<0.05	318	1.66
1	<0.005	0.69	<0.005	6.89	0.268	<0.0005	55.6	<0.01	21.6	0.11	0.12	0.010	<0.01	<0.1	18	3.35	<0.01	<0.3	226	<0.05	<0.6	<0.05	<0.005	0.090	3.27	389	3.80
2	<0.005	22.3		10.6	0.329	<0.0005	116.	<0.01		<0.05	0.11	<0.008	0.05		18	0.43	<0.01	0.3	289	<0.05	<0.6	<0.05			2.18		6.55
3	<0.005	31.6	<0.005	11.0	0.288	<0.0005	95.8	<0.01	28.0	<0.05	0.14	<0.008	0.07		19	0.01	<0.01	0.4	342	<0.05	<0.6	<0.05	<0.005	0.760	1.94	423	7.34
4	<0.005	34.0		10.8	0.364	<0.0005	71.5	<0.01		<0.05	0.16	<0.008	0.02		18	0.43	<0.01	0.4	369	<0.05	<0.6	<0.05			1.78		7.22
5	<0.005	38.8	0.006	11.5	0.402	<0.0005	42.8	<0.01	30.4	<0.05	0.19	<0.008	0.05	<0.1	19	0.02	<0.01	0.5	425	<0.05	<0.6	<0.05	<0.005	0.427	1.84	386	6.05
6	<0.005	51.0		12.9	0.433	<0.0005	33.5	<0.01		<0.05	0.22	<0.008	0.05		18	0.29	<0.01	0.5	476	<0.05	<0.6	<0.05			1.97		4.86
7	<0.005	47.0	0.007	14.9	0.085	<0.0005	20.4	<0.01	38.6	<0.05	0.27	<0.008	<0.01		20	0.02	<0.01	0.7	534	<0.05	<0.6	<0.05	<0.005	0.975	1.67	432	3.20
8	<0.005	69.7		16.8	0.433	<0.0005	21.8	<0.01		<0.05	0.30	<0.008	<0.01		19	0.72	<0.01	0.8	574	<0.05	<0.6	<0.05			1.89		2.78
9	<0.005	76.6	0.015	17.0	0.124	<0.0005	20.7	<0.01	25.0	<0.05	0.34	<0.008	0.05		22	0.03	<0.01	0.9	663	<0.05	<0.6	<0.05	<0.005	0.760	2.10	439	2.42
10	<0.005	74.5		17.2	0.414	<0.0005	18.6	<0.01		<0.05	0.34	<0.008	0.02		19	0.75	<0.01	0.9	607	<0.05	<0.6	<0.05			2.00		2.08
11	<0.005	81.5	0.012	18.7	0.106	0.0008	18.5	<0.01	23.8	0.07	0.37	<0.008	0.05	0.2	23	0.02	<0.01	1.2	695	<0.05	<0.6	<0.05	<0.005	0.055	3.06	696	2.09
12	<0.005	76.0		18.4	0.467	<0.0005	17.8	<0.01		<0.05	0.36	<0.008	<0.01		21	0.02	<0.01	1.2	676	<0.05	<0.6	<0.05			3.06		1.99
13	<0.005	80.7	0.015	18.1	0.381	<0.0005	16.2	<0.01	26.9	<0.05	0.41	<0.008	0.16	<0.1	22	0.02	<0.01	1.3	761	<0.05	0.7	<0.05	<0.005	0.060	3.94	750	1.91
14	<0.005	84.0		19.7	0.419	<0.0005	23.1	<0.01		<0.05	0.48	<0.008	0.08		23	1.50	<0.01	1.4	795	<0.05	<0.6	<0.05			3.63		2.35
15	<0.005	75.0	0.016	18.5	0.421	<0.0005	16.1	<0.01	28.3	<0.05	0.50	<0.008	<0.01		23	0.01	<0.01	1.4	828	<0.05	<0.6	<0.05	<0.005	0.072	3.65	820	2.12
16	<0.005	79.4		18.5	0.418	<0.0005	13.8	<0.01		<0.05	0.50	<0.008	0.01		21	0.16	<0.01	1.5	817	<0.05	<0.6	<0.05			4.23		1.62
17	<0.005	96.1	0.020	23.0	0.111	<0.0005	12.6	<0.01	28.0	0.06	0.75	0.010	0.07		24	0.08	<0.01	2.0	808	<0.05	0.7	<0.05	<0.005	0.054	5.95	1 040	1.66
18	<0.005	96.4		22.9	0.111	<0.0005	15.1	<0.01		<0.05	0.81	<0.008	0.04		24	0.74	<0.01	2.1	837	<0.05	0.8	<0.05			5.94		1.83
19	<0.005	100.0	0.022	25.1	0.104	<0.0005	14.5	<0.01	28.0	<0.05	0.89	<0.008	0.04		25	0.05	<0.01	2.3	904	<0.05	0.6	<0.05	<0.005	0.050	5.73	1 020	1.83
20	<0.005	96.1		25.0	0.088	<0.0005	22.8	<0.01		<0.05	0.91	<0.008	0.07		24	1.19	<0.01	2.4	879	<0.05	0.8	<0.05			5.61		2.51
21	<0.005	103.	0.015	24.9	0.117	0.0006	14.0	<0.01	28.0	<0.05	1.01	<0.008	0.09		25	0.04	<0.01	2.6	935	<0.05	0.6	<0.05	<0.005	0.055	6.38	1 090	2.18
22	<0.005	101.		25.8	0.437	<0.0005	20.2	<0.01		<0.05	1.04	<0.008	0.10		24	0.81	<0.01	3.2	968	<0.05	0.8	<0.05			6.48		2.61
23	<0.005	74.9	0.015	25.8	0.056	<0.0005	12.0	<0.01	29.0	<0.05	0.97	0.012	0.03		19	0.16	<0.01	2.5	989	<0.05	<0.6	<0.05	<0.005	0.055	4.86	1 360	1.45
24	<0.005	87.6		27.4	0.119	<0.0005	15.7	<0.01		<0.05	0.98	0.009	0.04		19	1.37	<0.01	2.5	980	<0.05	<0.6	<0.05			4.42		1.36
25	0.005	90.4	0.015	27.6	0.068	<0.0005	14.6	<0.01	29.0	<0.05	1.09	0.065	0.10	<0.1	19	0.08	<0.01	2.6	998	<0.05	<0.6	<0.05	<0.005	0.055	4.33	1 600	1.45
26	0.005	91.2		28.3	0.110	<0.0005	18.5	<0.01		<0.05	1.08	0.011	0.04		19	2.38	<0.01	2.7	1 020	<0.05	0.6	<0.05			3.98		1.48
27	<0.005	90.4	0.017	30.9	0.076	<0.0005	14.0	<0.01	31.0	<0.05	1.18	0.016	0.04		18	0.11	<0.01	2.7	1 030	<0.05	0.6	<0.05	<0.005	0.052	2.32	1 600	1.20
28	0.005	87.9		31.2	0.205	<0.0005	19.8	<0.01		<0.05	1.17	0.010	0.02		18	2.74	<0.01	2.7	1 030	<0.05	0.6	<0.05			2.97		1.53
29	0.008	81.3	0.019	31.3	0.076	<0.0005	15.2	<0.01	29.0	<0.05	1.21	0.017	0.02		17	0.10	<0.01	2.9	1 020	<0.05	0.6	0.05	<0.002	0.590	2.32	1 440	1.36
30	0.006	81.6	0.019	32.6	0.202	<0.0005	15.2	<0.01	29.0	<0.05	1.24	0.009	0.03	0.1	16	0.19	<0.01	2.9	1 030	<0.05	0.6	<0.05	<0.002	0.590	2.25	1 430	1.34

BOUNDARY DAM FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
<0.008	0.10	<0.1	17	32.2	<0.01	<0.3	199	<0.05	<0.6	<0.05	<0.005	<0.005	<0.05	318	1.66	<0.01	<0.005	<0.003	1.4	<0.005	<0.05	<0.05	1.08	216	1 010	8.25
0.010	<0.01	<0.1	18	3.35	<0.01	<0.3	226	<0.05	<0.6	<0.05	<0.005	0.090	3.27	389	3.80	0.05	<0.005	<0.003	<0.2	0.056	<0.05	<0.05	1.10	88	960	10.65
<0.008	0.05		18	0.43	<0.01	0.3	289	<0.05	<0.6	<0.05			2.18		6.55	<0.01	<0.005			0.039	<0.05	<0.05	1.70			11.55
<0.008	0.07		19	0.01	<0.01	0.4	342	<0.05	<0.6	<0.05	<0.005	0.760	1.94	423	7.34	<0.01	<0.005	<0.003		0.032	0.06	<0.05	1.80	405	1 370	11.50
<0.008	0.02		18	0.43	<0.01	0.4	369	<0.05	<0.6	<0.05			1.78		7.22	<0.01	<0.005			0.028	<0.05	<0.05	1.99			11.60
<0.008	0.05	<0.1	19	0.02	<0.01	0.5	425	<0.05	<0.6	<0.05	<0.005	0.427	1.84	386	6.05	<0.01	<0.005	<0.003	0.6	0.026	<0.05	<0.05	2.05	420	1 420	11.55
<0.008	0.05		18	0.29	<0.01	0.5	476	<0.05	<0.6	<0.05			1.97		4.86	<0.01	<0.005			0.027	0.14	<0.05	2.10			11.70
<0.008	<0.01		20	0.02	<0.01	0.7	534	<0.05	<0.6	<0.05	<0.005	0.975	1.67	432	3.20	<0.01	<0.005	<0.003		0.030	<0.05	<0.05	2.05	475	1 650	11.60
<0.008	<0.01		19	0.72	<0.01	0.8	574	<0.05	<0.6	<0.05			1.89		2.78	<0.01	<0.005			0.043	<0.05	<0.05	2.12			11.75
<0.008	0.05		22	0.03	<0.01	0.9	663	<0.05	<0.6	<0.05	<0.005	0.760	2.10	439	2.42	<0.01	<0.005	<0.002		0.055	<0.05	<0.05	2.40	605	1 890	11.80
<0.008	0.02		19	0.75	<0.01	0.9	607	<0.05	<0.6	<0.05			2.00		2.08	<0.01	<0.005			0.054	<0.05	<0.05	2.30			11.90
<0.008	0.05	0.2	23	0.02	<0.01	1.2	695	<0.05	<0.6	<0.05	<0.005	0.055	3.06	696	2.09	0.03	<0.005	<0.002		0.084	0.07	<0.05	2.51	685	2 020	11.90
<0.008	<0.01		21	0.02	<0.01	1.2	676	<0.05	<0.6	<0.05			3.06		1.99	<0.01	<0.005			0.074	<0.05	<0.05	2.70			11.65
<0.008	0.16	<0.1	22	0.02	<0.01	1.3	761	<0.05	0.7	<0.05	<0.005	0.060	3.94	750	1.91	0.02	<0.005	<0.002		0.080	0.31	<0.05	3.10	785	2 220	11.75
<0.008	0.08		23	1.50	<0.01	1.4	795	<0.05	<0.6	<0.05			3.63		2.35	<0.01	<0.005			0.090	<0.05	<0.05	3.35			11.95
<0.008	<0.01		23	0.01	<0.01	1.4	828	<0.05	<0.6	<0.05	<0.005	0.072	3.65	820	2.12	<0.01	<0.005	<0.002		0.074	<0.05	<0.05	3.35	885	2 360	12.10
<0.008	0.01		21	0.16	<0.01	1.5	817	<0.05	<0.6	<0.05			4.23		1.62	<0.01	<0.005			0.087	<0.05	<0.05	3.35			11.80
0.010	0.07		24	0.08	<0.01	2.0	808	<0.05	0.7	<0.05	<0.005	0.054	5.95	1 040	1.66	<0.01	<0.005	<0.002		0.134	<0.05	<0.05	3.35	900	2 630	11.90
<0.008	0.04		24	0.74	<0.01	2.1	837	<0.05	0.8	<0.05			5.94		1.83	<0.01	<0.005			0.152	<0.05	<0.05	3.70			11.95
<0.008	0.04		25	0.05	<0.01	2.3	904	<0.05	0.6	<0.05	<0.005	0.050	5.73	1 020	1.83	<0.01	<0.005	<0.002		0.151	0.06	<0.05	3.80	863	2 860	12.00
<0.008	0.07		24	1.19	<0.01	2.4	879	<0.05	0.8	<0.05			5.61		2.51	<0.01	0.008			0.158	<0.05	<0.05	3.70			11.90
<0.008	0.09		25	0.04	<0.01	2.6	935	<0.05	0.6	<0.05	<0.005	0.055	6.38	1 090	2.18	<0.01	<0.005	<0.002		0.160	0.08	<0.05	3.80	945	2 960	11.90
<0.008	0.10		24	0.81	<0.01	3.2	968	<0.05	0.8	<0.05			6.48		2.61	<0.01	<0.005			0.172	0.05	<0.05	3.65			11.95
0.012	0.03		19	0.16	<0.01	2.5	989	<0.05	<0.6	<0.05	<0.005	0.055	4.86	1 360	1.45	<0.01	<0.005	<0.002		0.127	0.06	<0.05	3.09	810	3 130	11.80
0.009	0.04		19	1.37	<0.01	2.5	980	<0.05	<0.6	<0.05			4.42		1.36	0.01	0.006			0.154	<0.05	<0.05	3.50			11.50
0.065	0.10	<0.1	19	0.08	<0.01	2.6	998	<0.05	<0.6	<0.05	<0.005	0.055	4.33	1 600	1.45	0.02	<0.005	<0.002		0.165	0.18	<0.05	3.40	855	3 230	11.10
0.011	0.04		19	2.38	<0.01	2.7	1 020	<0.05	0.6	<0.05			3.98		1.48	0.02	<0.005			0.168	<0.05	<0.05	3.65			11.35
0.016	0.04		18	0.11	<0.01	2.7	1 030	<0.05	0.6	<0.05	<0.005	0.052	2.32	1 600	1.20	0.02	<0.005	<0.002		0.149	0.06	<0.05	3.30	818	3 310	10.90
0.010	0.02		18	2.74	<0.01	2.7	1 030	<0.05	0.6	<0.05			2.97		1.53	0.02	<0.005			0.170	<0.05	<0.05	3.40			11.30
0.017	0.02		17	0.10	<0.01	2.9	1 020	<0.05	0.6	0.05	<0.002	0.590	2.32	1 440	1.36	0.04	<0.005	<0.002		0.167	<0.05	<0.05	3.30	760	3 280	11.00
0.009	0.03	0.1	16	0.19	<0.01	2.9	1 030	<0.05	0.6	<0.05	<0.002	0.590	2.25	1 430	1.34	0.02	<0.005	<0.002	4.0	0.168	<0.05	<0.05	3.50	760	3 370	11.20

BOUNDARY DAM BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th
0	<0.005	<0.01	0.006	2.76	0.311	<0.0005	68.4	<0.01	32.5	<0.05	0.62	<0.008	0.10	<0.1	17	32.2	<0.01	<0.3	199	<0.05	<0.6	<0.05	<0.005	<0.005	<0.05	318	1.66	<0.
1	<0.005	1.29	<0.005	5.02	0.160	<0.0005	62.1	0.01	26.3	0.06	0.60	0.010	0.05	0.2	18	32.8	<0.01	<0.3	200	<0.05	<0.6	<0.05	<0.005	<0.003	0.37	415	1.51	0.
2	<0.005	1.06		6.45	0.113	<0.0005	62.3	<0.01		<0.05	<0.01	0.009	0.04		17	33.4	<0.01	<0.3	217	<0.05	<0.6	<0.05			0.35		1.75	<0.
3	<0.005	0.62	<0.005	7.94	0.113	<0.0005	76.2	<0.01	24.7	<0.05	<0.01	<0.008	0.06		18	34.2	<0.01	<0.3	226	<0.05	<0.6	<0.05	<0.005	0.005	0.45	524	1.97	<0.
4	<0.005	0.39		9.43	0.094	<0.0005	88.3	<0.01		<0.05	<0.01	<0.008	0.13		18	37.2	<0.01	<0.3	238	<0.05	<0.6	<0.05			0.52		2.07	<0.
5	<0.005	0.26	<0.005	10.7	0.107	<0.0005	102.	<0.01	21.1	<0.05	<0.01	<0.008	0.05	0.1	18	42.0	<0.01	<0.3	250	<0.05	<0.6	<0.05	<0.005	0.010	0.67	698	2.30	0.
6	<0.005	0.25		12.0	0.098	<0.0005	109.	<0.01		<0.05	<0.01	<0.008	0.05		17	44.5	<0.01	<0.3	265	<0.05	<0.6	<0.05			0.69		2.43	<0.
7	<0.005	0.36	<0.005	13.2	0.094	<0.0005	129.	0.01	34.0	<0.05	<0.01	<0.008	0.05		21	48.6	<0.01	<0.3	311	<0.05	<0.6	<0.05	<0.005	0.018	0.91	828	2.70	0.
8	<0.005	0.17		13.8	0.078	<0.0005	126.	<0.01		<0.05	<0.01	<0.008	0.05		18	50.0	<0.01	<0.3	283	<0.05	<0.6	<0.05			0.86		2.60	<0.
9	<0.005	0.17	0.009	14.8	0.107	<0.0005	137.	<0.01	23.7	<0.05	<0.01	<0.008	0.08		19	56.2	<0.01	0.3	298	<0.05	<0.6	<0.05	<0.005	0.022	0.89	829	2.85	<0.
10	<0.005	0.19		15.5	0.078	<0.0005	140.	<0.01		<0.05	<0.01	<0.008	0.05		18	58.5	<0.01	<0.3	302	<0.05	<0.6	<0.05			0.73		2.82	<0.
11	<0.005	0.38	0.007	15.3	0.099	<0.0005	153.	0.02	24.2	0.10	0.05	0.012	0.11	0.2	20	62.6	<0.01	0.4	325	<0.05	0.8	<0.05	<0.005	<0.002	2.27	1 100	3.24	0.
12	<0.005	0.45		16.4	0.081	<0.0005	159.	0.02		0.07	0.06	0.010	0.11		19	65.8	<0.01	0.4	331	<0.05	0.9	<0.05			2.53		3.33	0.
13	<0.005	0.50	0.011	16.6	0.085	<0.0005	171.	0.02	28.3	0.10	0.05	0.019	0.13		19	73.2	<0.01	0.5	346	<0.05	0.8	<0.05	<0.005	0.002	2.46	1 180	3.38	0.
14	<0.005	0.54		17.2	0.079	<0.0005	173.	0.02		0.10	0.06	0.012	0.18		20	69.1	<0.01	0.4	355	<0.05	0.6	<0.05			2.50		3.58	0.
15	<0.005	0.54	0.011	17.6	0.096	<0.0005	183.	0.02	29.0	<0.05	0.05	<0.008	0.11	0.1	19	75.7	<0.01	0.5	372	<0.05	0.6	<0.05	<0.005	0.002	2.43	1 300	3.66	0.
16	<0.005	0.66		21.0	0.078	<0.0005	192.	0.02		<0.05	0.06	<0.008	0.05		19	77.7	<0.01	0.4	352	<0.05	0.6	<0.05			2.27		3.76	0.
17	<0.005	0.69	0.010	22.5	0.126	<0.0005	227.	0.01	29.0	<0.05	0.07	<0.008	0.09		23	95.7	<0.01	0.4	406	<0.05	0.9	<0.05	<0.005	0.003	2.93	1 400	4.84	<0.
18	<0.005	0.68		23.6	0.091	<0.0005	223.	0.01		<0.05	0.07	0.012	0.11		23	102.	<0.01	0.5	398	0.07	1.1	<0.05			3.08		4.92	0.
19	<0.005	0.76	0.015	26.5	0.113	<0.0005	243.	0.01	30.0	0.06	0.07	0.016	0.24		25	113.	<0.01	0.5	425	0.07	0.9	<0.05	<0.005	0.004	3.30	1 540	5.57	0.
20	<0.005	0.70		26.8	0.091	<0.0005	252.	0.02		<0.05	0.07	0.011	0.14		25	126.	<0.01	0.5	447	0.07	1.1	<0.05			2.95		5.40	0.
21	<0.005	0.62	0.010	26.0	0.084	<0.0005	232.	0.02	30.0	<0.05	0.06	0.010	0.09		23	119.	<0.01	0.5	422	<0.05	0.9	<0.05	<0.005	0.003	3.03	1 500	5.10	<0.
22	<0.005	0.64		28.4	0.084	<0.0005	247.	0.01		<0.05	0.07	0.016	0.40		25	133.	0.02	0.8	452	0.23	1.1	<0.05			3.10		5.83	0.
23	<0.005	0.86	0.008	27.3	0.075	<0.0005	238.	0.02	34.0	<0.05	0.05	0.017	0.07		22	149.	<0.01	0.5	439	0.09	0.7	<0.05	<0.005	0.004	1.02	1 700	5.33	0.
24	<0.005	0.97		28.1	0.112	<0.0005	235.	0.02		<0.05	0.06	0.016	0.09		21	150.	<0.01	0.4	440	0.07	0.8	<0.05			0.96		5.40	<0.
25	<0.005	0.85	0.022	29.2	0.076	<0.0005	246.	0.02	34.0	<0.05	0.05	0.013	0.11	<0.1	22	149.	<0.01	0.4	454	0.05	0.7	<0.05	<0.005	0.002	0.91	1 900	5.55	<0.
26	<0.005	0.94		29.9	0.073	<0.0005	254.	0.02		<0.05	0.06	0.024	0.10		22	161.	<0.01	0.4	457	0.05	0.8	<0.05			0.94		5.56	<0.
27	<0.005	0.92	0.017	29.9	0.069	<0.0005	259.	0.02	36.0	<0.05	0.07	0.025	0.10		22	161.	<0.01	0.4	471	0.06	0.7	<0.05	<0.005	0.005	0.84	2 100	5.66	<0.
28	<0.005	0.90		30.4	0.067	<0.0005	256.	0.02		<0.05	0.07	0.015	0.07		22	163.	<0.01	0.4	454	0.06	0.8	<0.05			0.81		5.56	0
29	<0.005	0.83	0.015	31.1	0.066	<0.0005	268.	0.02	36.0	0.05	0.07	0.015	0.07		23	170.	<0.01	0.5	468	0.06	0.8	<0.05	<0.002	0.012	0.75	2 120	5.74	0.
30	0.006	0.91	0.018	31.7	0.067	<0.0005	277.	0.02	36.0	0.05	0.08	0.018	0.09	0.1	23	178.	<0.01	0.5	478	0.06	0.8	<0.05	<0.002	0.009	0.77	2 170	6.02	0.

BOUNDARY DAM BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
0.62	<0.008	0.10	<0.1	17	32.2	<0.01	<0.3	199	<0.05	<0.6	<0.05	<0.005	<0.005	<0.05	318	1.66	<0.01	<0.005	<0.003	1.4	<0.005	0.13	<0.05	1.09	216	1 010	8.25
0.60	0.010	0.05	0.2	18	32.8	<0.01	<0.3	200	<0.05	<0.6	<0.05	<0.005	<0.003	0.37	415	1.51	0.03	<0.005	<0.003	2.0	0.030	<0.05	<0.05	1.00	146	979	8.55
<0.01	0.009	0.04		17	33.4	<0.01	<0.3	217	<0.05	<0.6	<0.05			0.35		1.75	<0.01	<0.005			0.019	<0.05	<0.05	1.20			8.55
<0.01	<0.008	0.06		18	34.2	<0.01	<0.3	226	<0.05	<0.6	<0.05	<0.005	0.005	0.45	524	1.97	<0.01	<0.005	<0.003		0.021	0.15	<0.05	1.22	104	1 150	8.55
<0.01	<0.008	0.13		18	37.2	<0.01	<0.3	238	<0.05	<0.6	<0.05			0.52		2.07	<0.01	<0.005			0.021	0.13	<0.05	1.35			8.50
<0.01	<0.008	0.05	0.1	18	42.0	<0.01	<0.3	250	<0.05	<0.6	<0.05	<0.005	0.010	0.67	698	2.30	0.01	<0.005	<0.003	< 0.2	0.021	<0.05	<0.05	1.40	100	1 350	8.35
<0.01	<0.008	0.05		17	44.5	<0.01	<0.3	265	<0.05	<0.6	<0.05			0.69		2.43	<0.01	<0.005			0.011	0.25	<0.05	1.40			8.70
<0.01	<0.008	0.05		21	48.6	<0.01	<0.3	311	<0.05	<0.6	<0.05	<0.005	0.018	0.91	828	2.70	0.01	<0.005	<0.003		0.016	<0.05	<0.05	1.52	106	1 520	8.55
<0.01	<0.008	0.05		18	50.0	<0.01	<0.3	283	<0.05	<0.6	<0.05			0.86		2.60	<0.01	<0.005			0.013	<0.05	<0.05	1.52			8.60
<0.01	<0.008	0.08		19	56.2	<0.01	0.3	298	<0.05	<0.6	<0.05	<0.005	0.022	0.89	829	2.85	<0.01	<0.005	<0.002		0.019	<0.05	<0.05	1.70	110	1 750	8.60
<0.01	<0.008	0.05		18	58.5	<0.01	<0.3	302	<0.05	<0.6	<0.05			0.73		2.82	<0.01	<0.005			0.010	0.06	<0.05	1.69			8.55
0.05	0.012	0.11	0.2	20	62.6	<0.01	0.4	325	<0.05	0.8	<0.05	<0.005	<0.002	2.27	1 100	3.24	0.07	0.006	<0.002	3.0	0.024	0.06	<0.05	1.80	114	1 740	8.55
0.06	0.010	0.11		19	65.8	<0.01	0.4	331	<0.05	0.9	<0.05			2.53		3.33	0.06	0.006			0.024	0.26	<0.05	1.90			8.55
0.05	0.019	0.13		19	73.2	<0.01	0.5	346	<0.05	0.8	<0.05	<0.005	0.002	2.46	1 180	3.38	0.08	0.006	<0.002		0.033	<0.05	<0.05	2.05	112	2 060	8.55
0.06	0.012	0.18		20	69.1	<0.01	0.4	355	<0.05	0.6	<0.05			2.50		3.58	0.08	0.006			0.036	<0.05	<0.05	2.10			8.50
0.05	<0.008	0.11	0.1	19	75.7	<0.01	0.5	372	<0.05	0.6	<0.05	<0.005	0.002	2.43	1 300	3.66	0.03	<0.005	<0.002		0.023	0.08	0.05	2.01	113	2 150	8.40
0.06	<0.008	0.05		19	77.7	<0.01	0.4	352	<0.05	0.6	<0.05			2.27		3.76	0.06	<0.005			0.014	0.05	<0.05	2.05			8.20
0.07	<0.008	0.09		23	95.7	<0.01	0.4	406	<0.05	0.9	<0.05	<0.005	0.003	2.93	1 400	4.84	<0.01	<0.005	<0.002		0.027	0.05	<0.05	2.15	117	2 430	8.05
0.07	0.012	0.11		23	102.	<0.01	0.5	398	0.07	1.1	<0.05			3.08		4.92	0.03	<0.005			0.034	<0.05	<0.05	2.35			8.25
0.07	0.016	0.24		25	113.	<0.01	0.5	425	0.07	0.9	<0.05	<0.005	0.004	3.30	1 540	5.57	0.04	<0.005	<0.002		0.037	0.07	<0.05	2.39	120	2 630	8.20
0.07	0.011	0.14		25	126.	<0.01	0.5	447	0.07	1.1	<0.05			2.95		5.40	0.02	<0.005			0.037	<0.05	<0.05	2.20			8.00
0.06	0.010	0.09		23	119.	<0.01	0.5	422	<0.05	0.9	<0.05	<0.005	0.003	3.03	1 500	5.10	<0.01	<0.005	<0.002		0.027	0.09	<0.05	2.21	116	2 940	8.00
0.07	0.016	0.40		25	133.	0.02	0.8	452	0.23	1.1	<0.05			3.10		5.83	0.01	<0.005			0.034	0.12	<0.05	2.40			8.25
0.05	0.017	0.07		22	149.	<0.01	0.5	439	0.09	0.7	<0.05	<0.005	0.004	1.02	1 700	5.33	0.01	<0.005	<0.002		0.030	0.11	<0.05	2.30	150	2 940	8.30
0.06	0.016	0.09		21	150.	<0.01	0.4	440	0.07	0.8	<0.05			0.96		5.40	<0.01	<0.005			0.024	0.23	<0.05	2.65			8.35
0.05	0.013	0.11	<0.1	22	149.	<0.01	0.4	454	0.05	0.7	<0.05	<0.005	0.002	0.91	1 900	5.55	<0.01	<0.005	<0.002		0.024	0.27	<0.05	2.60	155	3 520	7.70
0.06	0.024	0.10		22	161.	<0.01	0.4	457	0.05	0.8	<0.05			0.94		5.56	<0.01	<0.005			0.024	0.12	<0.05	3.00			8.15
0.07	0.025	0.10		22	161.	<0.01	0.4	471	0.06	0.7	<0.05	<0.005	0.005	0.84	2 100	5.66	<0.01	<0.005	<0.002		0.025	0.17	<0.05	2.90	158	3 390	8.40
0.07	0.015	0.07		22	163.	<0.01	0.4	454	0.06	0.8	<0.05			0.81		5.56	0.01	<0.005			0.029	0.12	<0.05	2.99			8.40
0.07	0.015	0.07		23	170.	<0.01	0.5	468	0.06	0.8	<0.05	<0.002	0.012	0.75	2 120	5.74	0.01	<0.005	<0.002		0.030	0.12	<0.05	2.95	163	3 690	8.40
0.08	0.018	0.09	0.1	23	178.	<0.01	0.5	478	0.06	0.8	<0.05	<0.002	0.009	0.77	2 170	6.02	0.02	<0.005	<0.002	11.5	0.026	0.12	<0.05	3.09	170	3 760	8.35

WABAMUM FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr
0	0.256	0.16	0.015	0.697	0.105	<0.0005	24.0	0.20	4.7	<0.05	0.02	<0.005	0.02	0.3	9	15.75	<0.01	<0.2	48	<0.05	0.7	0.10	<0.005	0.013	1.55	29	0.24
1	0.140	0.51	<0.005	5.33	0.468	<0.0005	61.8	0.20	3.8	<0.05	0.18	<0.005	0.02	<0.1	10	0.79	<0.01	<0.2	51	<0.05	0.8	<0.05	<0.005	0.015	18.7	102	0.59
2	0.157	1.11		7.61	0.130	<0.0005	116.	F0.10		<0.05	0.27	<0.005	0.02		11	0.61	<0.01	0.4	52	<0.05	0.8	<0.05			19.7		0.89
3	0.314	0.89	<0.005	8.98	0.170	<0.0005	146.	0.20	3.1	<0.05	0.35	<0.005	0.10		12	0.61	<0.01	0.7	51	<0.05	1.0	<0.05	<0.005	0.012	18.1	285	1.12
4	0.332	0.81		10.8	0.290	<0.0005	202.	0.20		<0.05	0.44	<0.005	0.04		13	0.44	<0.01	0.9	52	<0.05	1.1	<0.05			17.8		1.43
5	<0.005	0.57	<0.005	12.7	0.193	<0.0005	228.	0.02	6.2	<0.05	0.61	0.013	0.05	0.4	15	0.31	<0.01	0.7	141	0.07	0.6	<0.05	<0.005	0.010	13.0	473	1.63
6	<0.005	0.45		14.0	0.180	<0.0005	244.	0.02		<0.05	0.64	0.014	0.05		13	0.25	<0.01	0.8	49	0.07	0.8	<0.05			11.9		1.60
7	<0.005	0.56	<0.005	15.3	0.124	<0.0005	279.	0.02	3.6	<0.05	0.74	0.009	0.05		14	0.19	<0.01	0.8	237	0.08	0.8	<0.05	<0.005	0.033	12.1	643	1.93
8	<0.005	0.52		16.3	0.114	<0.0005	322.	0.02		<0.05	0.88	<0.008	0.05		14	0.85	<0.01	0.9	50	0.07	0.8	<0.05			10.6		2.12
9	<0.005	0.53	0.015	17.2	0.078	<0.0005	384.	0.02	15.5	0.05	1.06	0.011	0.17		18	0.31	<0.01	1.2	101	0.08	0.8	<0.05	<0.005	0.017	11.1	780	2.50
10	<0.005	0.66		18.9	0.082	<0.0005	372.	0.02		0.06	0.97	0.010	0.09		16	0.55	<0.01	1.3	59	0.07	0.8	<0.05			11.8		2.53
11	<0.005	0.63	<0.005	19.4	0.060	<0.0005	432.	0.03	4.6	0.17	1.11	0.017	0.14	0.2	20	0.27	<0.01	1.5	76	0.13	1.0	<0.05	<0.005	0.015	12.2	840	2.52
12	<0.005	1.03		18.7	0.081	<0.0005	440.	0.01		<0.05	1.11	<0.008	0.06		18	0.80	<0.01	1.7	65	<0.05	0.6	<0.05			9.64		2.78
13	<0.005	1.01	<0.005	19.4	0.057	<0.0005	467.	0.01	4.9	<0.05	1.20	0.008	0.06		19	0.48	<0.01	2.0	67	<0.05	0.6	<0.05	<0.005	0.007	9.48	963	2.85
14	<0.005	1.03		19.4	0.061	<0.0005	460.	0.01		<0.05	1.19	<0.008	0.08		18	0.49	<0.01	1.9	62	<0.05	0.6	<0.05			8.91		2.83
15	<0.005	0.98	<0.005	20.5	0.055	<0.0005	493.	0.01	3.1	<0.05	1.30	0.010	0.06	<0.1	20	0.41	<0.01	2.1	67	<0.05	0.6	<0.05	<0.005	<0.005	9.33	1 090	3.01
16	<0.005	0.92		20.8	0.053	<0.0005	490.	0.01		<0.05	1.28	0.009	0.05		19	0.47	<0.01	2.1	66	<0.05	0.7	<0.05			9.17		2.95
17	<0.005	0.74	<0.005	21.4	0.038	<0.0005	514.	0.01	5.2	<0.05	1.39	<0.008	0.06		20	0.57	<0.01	2.3	66	0.05	0.6	<0.05	<0.005		9.35	1 180	2.93
18	<0.005	0.76		21.0	0.042	<0.0005	503.	0.02		<0.05	1.36	<0.008	0.05		19	0.87	<0.01	2.2	62	0.05	0.7	<0.05			9.33		2.83
19	<0.005	0.81	0.036	20.7	0.047	<0.0005	552.	0.02	3.9	0.08	1.46	0.013	0.10		20	0.55	<0.01	2.3	63	0.08	0.9	<0.05	<0.005	<0.005	9.56	1 080	2.85
20	<0.005	0.78		20.5	0.049	<0.0005	521.	0.01		<0.05	1.38	<0.008	0.05		18	0.55	<0.01	2.2	57	<0.05	0.7	<0.05			8.65		2.79
21	<0.005	1.43	0.010	23.4	0.071	<0.0005	623.	0.03	2.9	0.09	1.79	0.020	0.12		17	0.58	<0.01	2.8	55	0.13	2.2	<0.05	<0.005	0.007	11.5	1 260	3.38
22	<0.005	1.75		21.8	0.067	<0.0005	568.	0.03		0.06	1.62	0.010	0.16		17	0.58	<0.01	2.6	56	0.08	2.0	<0.05			10.4		3.36
23	<0.005	1.77	0.035	22.9	0.054	<0.0005	618.	0.03	5.7	0.05	1.88	<0.008	0.16		18	0.56	<0.01	2.9	61	0.09	1.8	<0.05	<0.005	0.004	10.7	1 380	3.76
24	<0.005	1.76		23.5	0.052	<0.0005	595.	0.04		0.12	1.74	0.018	0.18		18	1.51	<0.01	2.8	59	0.09	1.7	<0.05			11.9		3.48
25	<0.005	1.77	0.018	24.3	0.045	<0.0005	628.	0.04	5.8	0.11	1.94	0.020	0.16	<0.1	18	1.02	<0.01	3.0	60	0.09	2.0	<0.05	<0.005	0.002	12.2	1 500	3.77
26	<0.005	1.39		25.4	0.074	<0.0005	607.	0.02		<0.05	1.97	0.010	0.21		19	1.04	<0.01	2.8	55	0.07	1.2	<0.05			15.6		3.71
27	<0.005	1.00	0.036	28.2	0.054	<0.0005	644.	0.02	5.1	<0.05	2.13	0.011	0.11		20	1.10	<0.01	2.9	57	0.07	1.3	<0.05	<0.005	<0.002	18.6	1 380	3.77
28	<0.005	1.05		28.1	0.054	<0.0005	652.	0.02		<0.05	2.08	0.012	0.09		20	1.40	<0.01	3.0	57	0.07	1.3	<0.05			17.3		3.67
29	<0.005	1.26	0.028	29.0	0.054	<0.0005	632.	0.02	5.5	0.07	2.27	0.016	0.11	<0.1	22	1.11	<0.01	3.3	58	0.09	1.5	<0.05	<0.005	0.006	16.2	1 480	3.92
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WABAMUM FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

Cr	Cu	Fe	Hg (µg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (µg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
0.02	<0.005	0.02	0.3	9	15.75	<0.01	<0.2	48	<0.05	0.7	0.10	<0.005	0.013	1.55	29	0.247	0.02	<0.005	<0.003	<1.0	0.006	<0.05	<0.02	0.35	192	250	8.45
0.18	<0.005	0.02	<0.1	10	0.79	<0.01	<0.2	51	<0.05	0.8	<0.05	<0.005	0.015	18.7	102	0.590	<0.01	<0.005	<0.003	<1.0	0.146	<0.05	<0.02	0.44	105	438	10.60
0.27	<0.005	0.02		11	0.61	<0.01	0.4	52	<0.05	0.8	<0.05			19.7		0.89	<0.01	<0.005			0.192	<0.05	<0.02	0.72			10.85
0.35	<0.005	0.10		12	0.61	<0.01	0.7	51	<0.05	1.0	<0.05	<0.005	0.012	18.1	285	1.12	0.03	<0.005	<0.003		0.193	0.08	<0.02	0.85	130	724	10.95
0.44	<0.005	0.04		13	0.44	<0.01	0.9	52	<0.05	1.1	<0.05			17.8		1.43	0.04	<0.005			0.202	<0.05	<0.02	1.06			11.20
0.61	0.013	0.05	0.4	15	0.31	<0.01	0.7	141	0.07	0.6	<0.05	<0.005	0.010	13.0	473	1.63	<0.01	<0.005	<0.003	<0.2	0.203	<0.05	<0.05	1.09	135	1 080	10.95
0.64	0.014	0.05		13	0.25	<0.01	0.8	49	0.07	0.8	<0.05			11.9		1.60	0.02	<0.005			0.192	<0.05	<0.05	1.28			11.00
0.74	0.009	0.05		14	0.19	<0.01	0.8	237	0.08	0.8	<0.05	<0.005	0.033	12.1	643	1.93	0.02	<0.005	<0.003		0.186	<0.05	<0.05	1.29	153	1 320	10.90
0.88	<0.008	0.05		14	0.85	<0.01	0.9	50	0.07	0.8	<0.05			10.6		2.12	0.02	<0.005			0.189	<0.05	<0.05	1.45			11.15
1.06	0.011	0.17		18	0.31	<0.01	1.2	101	0.08	0.8	<0.05	<0.005	0.017	11.1	780	2.50	0.01		<0.003	0.2	0.230	<0.05	<5.00	1.47	150	1 574	10.80
0.97	0.010	0.09		16	0.55	<0.01	1.3	59	0.07	0.8	<0.05			11.8		2.53	0.02	0.012			0.161	<0.05	<0.05	1.65			11.15
1.11	0.017	0.14	0.2	20	0.27	<0.01	1.5	76	0.13	1.0	<0.05	<0.005	0.015	12.2	840	2.52	0.10	0.011	<0.003	<0.2	0.177	0.10	<0.05	1.65	155	1 710	11.00
1.11	<0.008	0.06		18	0.80	<0.01	1.7	65	<0.05	0.6	<0.05			9.64		2.78	<0.01	<0.005			0.141	<0.05	<0.05	1.75			11.20
1.20	0.008	0.06		19	0.48	<0.01	2.0	67	<0.05	0.6	<0.05	<0.005	0.007	9.48	963	2.85	<0.01	<0.005	<0.003		0.135	<0.05	<0.05	1.70	155	1 830	10.80
1.19	<0.008	0.08		18	0.49	<0.01	1.9	62	<0.05	0.6	<0.05			8.91		2.83	<0.01	<0.005			0.127	<0.05	<0.05	1.85			11.00
1.30	0.010	0.06	<0.1	20	0.41	<0.01	2.1	67	<0.05	0.6	<0.05	<0.005	<0.005	9.33	1 090	3.01	<0.01	<0.005	<0.003	<0.2	0.130	0.08	<0.05	1.70	170	1 940	10.80
1.28	0.009	0.05		19	0.47	<0.01	2.1	66	<0.05	0.7	<0.05			9.17		2.95	<0.01	<0.005			0.123	<0.05	<0.05	1.80			10.85
1.39	<0.008	0.06		20	0.57	<0.01	2.3	66	0.05	0.6	<0.05	<0.005		9.35	1 180	2.93	<0.01	<0.005	<0.003		0.133	<0.05	<0.05	1.78	160	2 140	10.70
1.36	<0.008	0.05		19	0.87	<0.01	2.2	62	0.05	0.7	<0.05			9.33		2.83	<0.01	<0.005			0.131	<0.05	<0.05	1.80			11.00
1.46	0.013	0.10		20	0.55	<0.01	2.3	63	0.08	0.9	<0.05	<0.005	<0.005	9.56	1 080	2.85	0.02	<0.005	<0.002		0.143	<0.05	<0.05	2.05	183	2 330	11.15
1.38	<0.008	0.05		18	0.55	<0.01	2.2	57	<0.05	0.7	<0.05			8.65		2.79	<0.01	<0.005			0.120	<0.05	<0.05				
1.79	0.020	0.12		17	0.58	<0.01	2.8	55	0.13	2.2	<0.05	<0.005	0.007	11.5	1 260	3.38	0.09	0.005	<0.002		0.166	0.08	<0.05	2.00	190	2 640	11.45
1.62	0.010	0.16		17	0.58	<0.01	2.6	56	0.08	2.0	<0.05			10.4		3.36	0.06	<0.005			0.160	0.08	<0.05	2.07			11.05
1.88	<0.008	0.16		18	0.56	<0.01	2.9	61	0.09	1.8	<0.05	<0.005	0.004	10.7	1 380	3.76	0.09	<0.005	<0.002		0.158	0.08	<0.05	2.01	193	2 420	10.70
1.74	0.018	0.18		18	1.51	<0.01	2.8	59	0.09	1.7	<0.05			11.9		3.48	0.07	<0.005			0.172	0.05	<0.05	2.09			10.95
1.94	0.020	0.16	<0.1	18	1.02	<0.01	3.0	60	0.09	2.0	<0.05	<0.005	0.002	12.2	1 500	3.77	0.13	<0.005	<0.002		0.184	0.06	<0.05	1.92	165	2 450	10.70
1.97	0.010	0.21		19	1.04	<0.01	2.8	55	0.07	1.2	<0.05			15.6		3.71	<0.01	0.013			0.173	<0.05	<0.05	2.12			10.65
2.13	0.011	0.11		20	1.10	<0.01	2.9	57	0.07	1.3	<0.05	<0.005	<0.002	18.6	1 380	3.77	<0.01	<0.005	<0.002		0.199	<0.05	<0.05	1.92	173	2 640	10.50
2.08	0.012	0.09		20	1.40	<0.01	3.0	57	0.07	1.3	<0.05			17.3		3.67	<0.01	<0.005			0.195	<0.05	<0.05	2.05			10.90
2.27	0.016	0.11	<0.1	22	1.11	<0.01	3.3	58	0.09	1.5	<0.05	<0.005	0.006	16.2	1 480	3.92	<0.01	<0.005	<0.002	9.0	0.205	<0.05	<0.05	1.90	180	2 560	11.00

WABAMUM BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOT

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4
0	0.256	0.16	0.015	0.697	0.105	<0.0005	24.0	0.20	4.7	<0.05	0.02	<0.005	0.02	0.3	9	15.7	<0.01	<0.2	48	<0.05	0.7	0.10	0.005	0.013	1.55	79
1	0.357	<0.05	<0.005	2.27	0.155	<0.0005	27.8	0.20	2.7	<0.05	0.01	<0.005	<0.01	<0.1	10	14.3	<0.01	0.4	50	<0.05	0.9	<0.05	<0.005	0.015	7.86	56
2	0.065	0.14		3.81	0.130	<0.0005	30.1	0.20		<0.05	<0.01	<0.005	0.02		9	14.8	<0.01	<0.2	55	<0.05	<0.5	<0.05			12.8	
3	0.318	0.11	0.015	4.66	0.124	<0.0005	34.1	0.20	4.7	<0.05	<0.01	<0.005	0.19		10	15.3	<0.01	0.3	55	<0.05	1.0	<0.05	<0.005	0.015	16.3	66
4	<0.005	0.13		6.40	0.110	<0.0005	35.2	0.20		<0.05	0.02	<0.005	0.02		10	16.0	<0.01	<0.2	57	<0.05	0.7	<0.05			18.5	
5	<0.005	<0.01	0.015	7.91	0.099	<0.0005	41.1	0.01	3.5	<0.05	0.37	<0.008	0.03	0.4	9	15.6	<0.01	0.3	51	<0.05	<0.6	<0.05	<0.005	0.012	15.8	96
6	<0.005	<0.01		9.28	0.087	<0.0005	43.1	<0.01		<0.05	0.37	0.009	<0.01		7	16.5	<0.01	0.3	51	<0.05	<0.6	<0.05			17.3	
7	<0.005	<0.01	0.055	10.8	0.098	<0.0005	46.9	<0.01	4.8	<0.05	0.41	<0.008	<0.01		8	18.3	<0.01	0.4	54	<0.05	<0.6	<0.05	<0.005	0.015	18.6	152
8	<0.005	<0.01		12.1	0.080	<0.0005	52.6	<0.01		<0.05	0.45	<0.008	<0.01		8	19.3	<0.01	0.4	54	<0.05	<0.6	<0.05			19.4	
9	<0.005	<0.01	0.084	13.0	0.085	<0.0005	60.1	0.01	4.8	<0.05	0.49	<0.008	0.06		8	22.0	<0.01	0.5	58	<0.05	<0.6	<0.05	<0.005	0.005	20.9	189
10	<0.005	<0.01		13.6	0.076	<0.0005	59.6	<0.01		<0.05	0.50	<0.008	<0.01		9	22.6	<0.01	0.5	64	<0.05	<0.6	<0.05			20.5	
11	<0.005	<0.01	0.095	14.9	0.081	0.0005	66.6	<0.01	5.9	<0.05	0.51	<0.008	<0.01	1.3	10	25.1	<0.01	0.6	72	<0.05	<0.6	<0.05	<0.005	0.005	25.9	147
12	<0.005	<0.01		14.9	0.094	<0.0005	72.1	<0.01		<0.05	0.01	<0.008	<0.01		9	25.4	<0.01	0.7	68	<0.05	<0.6	<0.05			21.6	
13	<0.005	<0.01	0.075	16.5	0.097	<0.0005	81.9	<0.01	7.6	<0.05	0.04	<0.008	0.08		10	27.3	<0.01	0.8	78	<0.05	<0.6	<0.05	<0.005	0.005	21.9	166
14	<0.005	<0.01		16.5	0.085	<0.0005	82.4	<0.01		<0.05	<0.01	0.011	0.03		9	28.1	<0.01	0.8	72	<0.05	<0.6	<0.05			22.0	
15	<0.005	<0.01	0.040	17.6	0.096	<0.0005	93.5	<0.01	5.8	<0.05	<0.01	<0.008	0.03	0.1	10	30.7	<0.01	0.9	75	<0.05	<0.6	<0.05	<0.005	<0.005	23.4	196
16	<0.005	<0.01		18.3	0.092	<0.0005	96.7	<0.01		<0.05	<0.01	<0.008	0.03		9	31.4	<0.01	0.9	74	<0.05	0.6	<0.05			22.8	
17	<0.005	<0.01	0.083	18.8	0.107	<0.0005	106	<0.01	10.2	<0.05	<0.01	<0.008	0.04		10	33.9	<0.01	1.0	76	<0.05	0.6	<0.05	<0.005	<0.005	22.5	228
18	<0.005	<0.01		19.3	0.090	<0.0005	108	<0.01		<0.05	<0.01	<0.008	0.03		9	33.5	<0.01	1.0	76	<0.05	0.6	<0.05			23.2	
19	<0.005	<0.01	0.060	20.0	0.126	<0.0005	115	<0.01	6.8	<0.05	<0.01	<0.008	0.03		10	35.1	<0.01	1.1	77	<0.05	<0.6	<0.05	<0.005	<0.005	23.9	174
20	<0.005	<0.01		20.5	0.108	<0.0005	110	<0.01		<0.05	<0.01	<0.008	0.05		9	33.9	<0.01	1.1	73	<0.05	<0.6	<0.05			23.1	
21	<0.005	<0.01	0.036	21.5	0.110	<0.0005	118	0.02	5.6	0.12	0.09	0.011	0.05		8	36.7	<0.01	1.2	66	0.06	0.8	<0.05	<0.005	<0.002	28.0	338
22	<0.005	0.03		22.6	0.110	<0.0005	118	0.02		<0.05	0.09	0.014	0.03		8	36.6	<0.01	1.3	64	0.07	1.0	<0.05			25.7	
23	<0.005	0.01	0.065	23.0	0.125	<0.0005	126	<0.01	8.3	<0.05	0.09	0.008	<0.01		8	39.2	<0.01	1.3	68	<0.05	0.8	<0.05	<0.005	<0.002	27.1	440
24	<0.005	0.03		24.2	0.112	0.0005	118	0.02		0.09	0.09	0.014	0.03		7	37.6	<0.01	1.2	64	<0.05	1.0	<0.05			25.7	
25	<0.005	0.02	0.058	23.3	0.122	<0.0005	123	0.02	8.3	<0.05	0.09	0.013	0.03	<0.1	7	37.4	<0.01	1.4	64	0.05	1.0	<0.05	<0.005	<0.002	26.8	430
26	<0.005	0.08		26.0	0.118	<0.0005	127	<0.01		<0.05	0.10	0.011	0.03		9	40.4	<0.01	1.3	70	<0.05	0.8	<0.05			29.6	
27	<0.005	0.11	0.058	27.3	0.126	<0.0005	138	<0.01	8.7	<0.05	0.10	0.011	0.07		10	43.1	<0.01	1.4	75	<0.05	0.7	<0.05	<0.005	<0.002	29.1	490
28	<0.005	0.17		29.1	0.125	<0.0005	142	<0.01		<0.05	0.10	0.011	0.04		9	45.6	<0.01	1.4	74	<0.05	0.7	<0.05			28.9	
29	<0.005	0.16	0.080	29.0	0.130	<0.0005	144	<0.01	7.6	<0.05	0.11	<0.008	0.07	<0.1	9	45.3	<0.01	1.4	74	<0.05	0.8	<0.05	<0.005	<0.002	28.3	475
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WABAMUM BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
0.02	<0.005	0.02	0.3	9	15.7	<0.01	<0.2	48	<0.05	0.7	0.10	0.005	0.013	1.55	79	0.247	0.02	<0.005	<0.003	<1.0	0.006	<0.05	<0.02	0.35	192	250	8.45
0.01	<0.005	<0.01	<0.1	10	14.3	<0.01	0.4	50	<0.05	0.9	<0.05	<0.005	0.015	7.86	56	0.271	0.06	<0.005	<0.003	2.0	0.068	<0.05	<0.02	0.35	160	298	8.35
<0.01	<0.005	0.02		9	14.8	<0.01	<0.2	55	<0.05	<0.5	<0.05			12.8		0.290	<0.01	<0.005			0.129	<0.05	<0.02	0.40			8.45
<0.01	<0.005	0.19		10	15.3	<0.01	0.3	55	<0.05	1.0	<0.05	<0.005	0.015	16.3	66	0.287	<0.01	<0.005	<0.003		0.160	<0.05	<0.02	0.41	148	351	8.40
0.02	<0.005	0.02		10	16.0	<0.01	<0.2	57	<0.05	0.7	<0.05			18.5		0.300	<0.01	<0.005			0.201	<0.05	<0.02	0.45			8.40
0.37	<0.008	0.03	0.4	9	15.6	<0.01	0.3	51	<0.05	<0.6	<0.05	<0.005	0.012	15.8	96	0.256	<0.01	<0.005	<0.003	7.0	0.234	<0.05	<0.05	0.48	152	179	8.30
0.37	0.009	<0.01		7	16.5	<0.01	0.3	51	<0.05	<0.6	<0.05			17.3		0.262	<0.01	<0.005			0.245	<0.05	<0.05	0.53			8.35
0.41	<0.008	<0.01		8	18.3	<0.01	0.4	54	<0.05	<0.6	<0.05	<0.005	0.015	18.6	152	0.310	<0.01	<0.005	<0.003		0.275	<0.05	<0.05	0.56	132	508	8.35
0.45	<0.008	<0.01		8	19.3	<0.01	0.4	54	<0.05	<0.6	<0.05			19.4		0.316	<0.01	<0.005			0.296	<0.05	<0.05	0.59			8.20
0.49	<0.008	0.06		8	22.0	<0.01	0.5	58	<0.05	<0.6	<0.05	<0.005	0.005	20.9	189	0.379	<0.01	<0.005	<0.003		0.331	<0.05	<0.05	0.64	148	273	8.20
0.50	<0.008	<0.01		9	22.6	<0.01	0.5	64	<0.05	<0.6	<0.05			20.5		0.433	<0.01	<0.005			0.350	<0.05	<0.05	0.66			8.20
0.51	<0.008	<0.01	1.3	10	25.1	<0.01	0.6	72	<0.05	<0.6	<0.05	<0.005	0.005	25.9	147	0.450	<0.01	<0.005	<0.003	23.0	0.374	<0.05	<0.05	0.70	128	668	8.20
0.01	<0.008	<0.01		9	25.4	<0.01	0.7	68	<0.05	<0.6	<0.05			21.6		0.455	<0.01	<0.005			0.365	<0.05	<0.05	0.72			8.10
0.04	<0.008	0.08		10	27.3	<0.01	0.8	78	<0.05	<0.6	<0.05	<0.005	0.005	21.9	166	0.478	<0.01	<0.005	<0.003		0.398	<0.05	<0.05	0.74	124	670	8.00
<0.01	0.011	0.03		9	28.1	<0.01	0.8	72	<0.05	<0.6	<0.05			22.0		0.496	<0.01	<0.005			0.381	<0.05	<0.05	0.78			7.90
<0.01	<0.008	0.03	0.1	10	30.7	<0.01	0.9	75	<0.05	<0.6	<0.05	<0.005	<0.005	23.4	196	0.532	<0.01	<0.005	<0.003	1.2	0.413	<0.05	<0.05	0.77	133	757	8.15
<0.01	<0.008	0.03		9	31.4	<0.01	0.9	74	<0.05	0.6	<0.05			22.8		0.589	<0.01	<0.005			0.403	<0.05	<0.05	0.80			8.20
<0.01	<0.008	0.04		10	33.9	<0.01	1.0	76	<0.05	0.6	<0.05	<0.005	<0.005	22.5	228	0.620	<0.01	<0.005	<0.003		0.415	<0.05	<0.05	0.82	147	873	8.35
<0.01	<0.008	0.03		9	33.5	<0.01	1.0	76	<0.05	0.6	<0.05			23.2		0.652	<0.01	<0.005			0.421	<0.05	<0.05	0.86			8.35
<0.01	<0.008	0.03		10	35.1	<0.01	1.1	77	<0.05	<0.6	<0.05	<0.005	<0.005	23.9	174	0.669	0.02	<0.005	<0.002		0.444	<0.05	<0.05	0.91	143	908	8.45
<0.01	<0.008	0.05		9	33.9	<0.01	1.1	73	<0.05	<0.6	<0.05			23.1		0.660	0.01	<0.005			0.421	<0.05	<0.05	0.80			8.30
0.09	0.011	0.05		8	36.7	<0.01	1.2	66	0.06	0.8	<0.05	<0.005	<0.002	28.0	338	0.709	0.03	<0.005	<0.002		0.492	<0.05	<0.05	0.86	134	931	8.30
0.09	0.014	0.03		8	36.6	<0.01	1.3	64	0.07	1.0	<0.05			25.7		0.683	0.07	<0.005			0.470	0.06	<0.05	0.84			8.20
0.09	0.008	<0.01		8	39.2	<0.01	1.3	68	<0.05	0.8	<0.05	<0.005	<0.002	27.1	440	0.719	<0.01	<0.005	<0.002		0.488	<0.05	<0.05	0.86	138	968	8.30
0.09	0.014	0.03		7	37.6	<0.01	1.2	64	<0.05	1.0	<0.05			25.7		0.715	0.05	<0.005			0.464	<0.05	<0.05	0.96			8.30
0.09	0.013	0.03	<0.1	7	37.4	<0.01	1.4	64	0.05	1.0	<0.05	<0.005	<0.002	26.8	430	0.714	0.05	<0.005	<0.002		0.473	<0.05	<0.05	0.91	127	953	8.35
0.10	0.011	0.03		9	40.4	<0.01	1.3	70	<0.05	0.8	<0.05			29.6		0.816	0.02	<0.005			0.481	0.07	<0.05	1.03			8.20
0.10	0.011	0.07		10	43.1	<0.01	1.4	75	<0.05	0.7	<0.05	<0.005	<0.002	29.1	490	0.868	0.03	<0.005	<0.002		0.497	<0.05	<0.05	0.99	130	1 100	8.20
0.10	0.011	0.04		9	45.6	<0.01	1.4	74	<0.05	0.7	<0.05			28.9		0.903	0.03	<0.005			0.497	<0.05	<0.05	1.02			8.15
0.11	<0.008	0.07	<0.1	9	45.3	<0.01	1.4	74	<0.05	0.8	<0.05	<0.005	<0.002	28.3	475	0.913	0.03	<0.005	<0.002		0.501	<0.05	<0.05	0.99	133	1 060	8.25

SUNDANCE FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO4	Sr
0	0.082	<0.05	0.008	0.944	0.291	<0.0005	46.9	0.20	14.1	<0.05	0.02	0.013	0.06	0.6	7	27.2	<0.01	0.2	70	<0.05	0.9	0.15	<0.005	0.005	4.09	145	0.931
1	0.246	3.78	<0.005	3.45	0.136	<0.0005	162.	0.20	7.6	<0.05	0.14	<0.005	0.11	<0.1	8	0.06	<0.01	0.2	73	<0.05	1.0	<0.05	0.005	0.012	7.09	124	2.31
2	0.283	0.79		3.23	0.209	<0.0005	188.	<0.10		<0.05	0.17	<0.005	0.09		8	<0.01	<0.01	0.2	79	<0.05	1.0	<0.05			2.78		4.13
3	0.102	0.45	<0.005	3.36	0.490	<0.0005	392.	0.20	11.0	<0.05	0.20	<0.005	0.03		8	0.07	<0.01	0.3	84	<0.05	1.2	<0.05	<0.005	0.035	2.42	208	6.19
4	0.120	0.35		3.29	0.491	<0.0005	469.	0.20		<0.05	0.21	<0.005	0.03		9	0.07	<0.01	0.4	86	<0.05	1.5	<0.05			1.42		7.58
5	<0.005	0.40	<0.005	3.81	0.558	<0.0005	568.	0.05	11.1	0.19	0.29	0.021	0.28	0.4	8	<0.01	<0.01	0.6	119	0.17	1.8	<0.05	<0.005	0.037	0.67	193	8.83
6	<0.005	0.31		3.53	0.545	<0.0005	480.	0.03		0.11	0.26	0.015	0.17		7	0.80	<0.01	0.6	91	0.14	1.4	<0.05			0.85		8.95
7	<0.005	0.26	<0.005	3.62	0.621	<0.0005	525.	0.05	14.0	0.11	0.26	0.014	0.22		7	<0.01	<0.01	0.6	207	0.15	1.5	<0.05	<0.005	0.035	0.68	161	10.6
8	<0.005	0.12		3.84	0.510	<0.0005	430.	0.02		<0.05	0.25	<0.008	0.05		5	0.67	<0.01	0.5	99	0.07	0.8	<0.05			0.89		10.0
9	<0.005	0.12	<0.005	3.50	0.587	<0.0005	466.	0.02	11.9	<0.05	0.26	0.008	0.11		6	<0.01	<0.01	0.6	103	0.05	0.8	<0.05	<0.005	0.040	0.36	140	10.6
10	<0.005	0.35		3.19	0.696	<0.0005	404.	0.02		<0.05	0.23	<0.008	0.10		5	<0.01	<0.01	0.7	119	<0.05	0.6	<0.05			0.61		11.3
11	<0.005	0.28	<0.005	3.00	0.791	<0.0005	436.	0.02	14.8	<0.05	0.23	<0.008	0.10	0.3	6	<0.01	<0.01	0.8	134	0.07	0.7	<0.05	<0.005	0.035	0.61	109	12.3
12	<0.005	0.61		2.76	0.779	<0.0005	381.	0.01		<0.05	0.19	<0.008	0.02		6	0.83	<0.01	0.8	124	<0.05	0.6	<0.05			1.73		9.85
13	<0.005	0.76	<0.005	2.33	0.919	<0.0005	391.	0.01	14.3	<0.05	0.19	<0.008	0.02		8	<0.01	<0.01	0.9	204	<0.05	<0.6	<0.05	<0.005	0.035	0.95	111	10.3
14	<0.005	1.02		2.19	0.985	<0.0005	363.	0.01		<0.05	0.18	<0.008	0.01		6	0.11	<0.01	0.9	124	<0.05	<0.6	<0.05			1.16		9.47
15	<0.005	0.77	<0.005	1.98	1.01	<0.0005	356.	0.01	11.8	<0.05	0.19	<0.008	0.02	0.2	7	<0.01	<0.01	0.9	127	<0.05	<0.6	<0.05	<0.005	0.040	0.75	43	9.18
16	<0.005	0.84		1.57	1.08	<0.0005	312.	<0.01		<0.05	0.17	<0.008	0.01		5	<0.01	<0.01	0.9	119	<0.05	<0.6	<0.05			1.03		8.26
17	<0.005	0.80	<0.005	1.41	0.868	<0.0005	244.	0.01	17.1	<0.05	0.18	<0.008	0.01		6	<0.01	<0.01	0.9	129	<0.05	<0.6	<0.05	<0.005	0.025	1.04	73	6.64
18	<0.005	0.83		1.29	0.835	<0.0005	215.	<0.01		<0.05	0.18	<0.008	0.01		5	0.06	<0.01	0.8	124	<0.05	<0.6	<0.05			1.69		5.67
19	<0.005	1.00	0.004	0.895	1.03	<0.0005	232.	0.01	10.7	<0.05	0.20	<0.008	0.02		5	<0.01	<0.01	1.0	143	<0.05	<0.6	<0.05	<0.005	0.025	1.98	55	5.47
20	<0.005	0.92		0.762	0.912	<0.0005	203.	<0.01		<0.05	0.19	<0.008	0.01		4	<0.01	<0.01	0.9	123	<0.05	<0.6	<0.05			1.59		4.77
21	<0.005	1.16	0.003	0.778	1.10	<0.0005	184.	<0.01	10.2	<0.05	0.25	<0.008	0.10		5	0.04	<0.01	1.1	159	0.06	1.0	<0.05	<0.005	0.030	4.04	63	4.88
22	<0.005	1.09		0.721	1.01	<0.0005	166.	<0.01		<0.05	0.28	<0.008	0.07		4	0.17	<0.01	1.0	119	<0.05	<0.6	<0.05			4.04		4.24
23	<0.005	2.09	0.006	0.662	0.925	<0.0005	115.	<0.01	15.7	0.07	0.37	<0.008	0.07		5	<0.01	<0.01	1.2	140	<0.05	<0.6	<0.05	<0.005	0.035	5.20	67	3.78
24	<0.005	2.51		0.958	0.662	<0.0005	88.2	0.01		<0.05	0.44	0.008	0.02		4	0.17	<0.01	1.2	118	<0.05	0.8	<0.05			5.70		2.68
25	<0.005	3.72	0.002	1.89	0.653	<0.0005	136.	0.02	12.5	0.08	0.43	0.013	0.03	0.2	4	<0.01	<0.01	1.4	117	<0.05	1.0	<0.05	<0.005	0.045	3.46	110	2.99
26	<0.005	2.40		1.77	0.681	<0.0005	146.	0.02		0.08	0.38	0.011	0.03		4	0.03	<0.01	1.2	112	<0.05	1.0	<0.05			3.17		3.63
27	<0.005	2.43	0.002	1.79	0.607	<0.0005	132.	<0.01	12.0	<0.05	0.44	<0.008	0.03		5	0.01	<0.01	1.3	130	<0.05	0.6	<0.05	<0.005	0.045	3.74	140	3.46
28	<0.005	2.82		1.66	0.540	<0.0005	107.	<0.01		<0.05	0.43	<0.008	0.01		4	0.03	<0.01	1.2	128	<0.05	0.6	<0.05			4.71		3.19
29	<0.005	4.06	0.002	1.96	0.503	<0.0005	70.5	<0.01	14.0	<0.05	0.45	<0.008	0.06		5	<0.01	<0.01	1.3	136	<0.05	<0.6	<0.05	<0.005	0.040	4.93	111	2.66
30	<0.005	5.80	0.007	2.45	0.557	<0.0005	87.5	<0.01	10.0	<0.05	0.50	<0.008	0.03	<0.2	5	0.03	<0.01	1.3	133	<0.05	<0.6	<0.05	<0.005	0.046	5.03	102	2.74

SUNDANCE FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
0.02	0.013	0.06	0.6	7	27.2	<0.01	0.2	70	<0.05	0.9	0.15	<0.005	0.005	4.09	145	0.931	<0.01	<0.005	0.003	3.0	<0.005	0.[illegible]3	<0.02	0.65	148	460	8.65
0.14	<0.005	0.11	<0.1	8	0.06	<0.01	0.2	73	<0.05	1.0	<0.05	0.005	0.012	7.09	124	2.31	<0.01	<0.005	<0.003	<1.0	0.042	<0.05	<0.02	1.30	260	702	11.10
0.17	<0.005	0.09		8	<0.01	<0.01	0.2	79	<0.05	1.0	<0.05			2.78		4.13	<0.01	<0.005			<0.005	0.05	<0.02	2.59			11.85
0.20	<0.005	0.03		8	0.07	<0.01	0.3	84	<0.05	1.2	<0.05	<0.005	0.035	2.42	208	6.19	<0.01	<0.005	0.004		<0.005	0.18	<0.02	3.50	765	1 200	12.05
0.21	<0.005	0.03		9	0.07	<0.01	0.4	86	<0.05	1.5	<0.05			1.42		7.58	<0.01	<0.005			<0.005	0.08	<0.02	3.90			12.15
0.29	0.021	0.28	0.4	8	<0.01	<0.01	0.6	119	0.17	1.8	<0.05	<0.005	0.037	0.67	193	8.83	0.01	0.015	0.004	<0.2	0.025	0.06	<0.05	4.70	1 160	1 480	12.10
0.26	0.015	0.17		7	0.80	<0.01	0.6	91	0.14	1.4	<0.05			0.85		8.95	<0.01	<0.005			0.014	0.06	<0.05	5.00			12.05
0.26	0.014	0.22		7	<0.01	<0.01	0.6	207	0.15	1.5	<0.05	<0.005	0.035	0.68	161	10.6	<0.01	<0.005	<0.003		0.021	0.15	<0.05	5.10	1 220	1 560	12.10
0.25	<0.008	0.05		5	0.67	<0.01	0.5	99	0.07	0.8	<0.05			0.89		10.0	<0.01	<0.005			<0.005	<0.05	<0.05	4.60			12.05
0.26	0.008	0.11		6	<0.01	<0.01	0.6	103	0.05	0.8	<0.05	<0.005	0.040	0.36	140	10.6	<0.01	<0.005	<0.003		0.005	0.61	<0.05	4.50	1 110	1 450	12.10
0.23	<0.008	0.10		5	<0.01	<0.01	0.7	119	<0.05	0.6	<0.05			0.61		11.3	<0.01	0.012			<0.005	<0.05	<0.05	4.40			12.15
0.23	<0.008	0.10	0.3	6	<0.01	<0.01	0.8	134	0.07	0.7	<0.05	<0.005	0.035	0.61	109	12.3	<0.01	0.012	<0.003	<0.2	0.005	0.08	<0.05	4.50	1 070	1 420	12.20
0.19	<0.008	0.02		6	0.83	<0.01	0.8	124	<0.05	0.6	<0.05			1.73		9.85	<0.01	<0.005			<0.005	<0.05	<0.05	4.30			12.20
0.19	<0.008	0.02		8	<0.01	<0.01	0.9	204	<0.05	<0.6	<0.05	<0.005	0.035	0.95	111	10.3	<0.01	<0.005	<0.003		<0.005	<0.11	<0.05	4.00	1 010	1 330	12.05
0.18	<0.008	0.01		6	0.11	<0.01	0.9	124	<0.05	<0.6	<0.05			1.16		9.47	<0.01	<0.005			<0.005	<0.05	<0.05	4.00			12.00
0.19	<0.008	0.02	0.2	7	<0.01	<0.01	0.9	127	<0.05	<0.6	<0.05	<0.005	0.040	0.75	43	9.18	<0.01	<0.005	<0.003	<0.2	0.006	<0.05	<0.05	3.60	870	1 120	12.05
0.17	<0.008	0.01		5	<0.01	<0.01	0.9	119	<0.05	<0.6	<0.05			1.03		8.26	<0.01	<0.005			<0.005	<0.05	<0.05	3.00			12.00
0.18	<0.008	0.01		6	<0.01	<0.01	0.9	129	<0.05	<0.6	<0.05	<0.005	0.025	1.04	73	6.64	0.03	<0.005	<0.003		0.005	<0.05	<0.05	3.10	715	897	12.10
0.18	<0.008	0.01		5	0.06	<0.01	0.8	124	<0.05	<0.6	<0.05			1.69		5.67	<0.01	<0.005			<0.005	<0.05	<0.05	2.80			12.20
0.20	<0.008	0.02		5	<0.01	<0.01	1.0	143	<0.05	<0.6	<0.05	<0.005	0.025	1.98	55	5.47	0.01	<0.005	<0.002		0.009	0.06	<0.05	2.82	760	846	12.15
0.19	<0.008	0.01		4	<0.01	<0.01	0.9	123	<0.05	<0.6	<0.05			1.59		4.77	<0.01	<0.005			<0.005	<0.05	<0.05	2.55			12.30
0.25	<0.008	0.10		5	0.04	<0.01	1.1	159	0.06	1.0	<0.05	<0.005	0.030	4.04	63	4.88	0.05	<0.005	<0.002		0.019	0.11	<0.05	2.40	610	678	12.15
0.28	<0.008	0.07		4	0.17	<0.01	1.0	119	<0.05	<0.6	<0.05			4.04		4.24	<0.01	<0.005			0.013	<0.05	<0.05	2.10			11.90
0.37	<0.008	0.07		5	<0.01	<0.01	1.2	140	<0.05	<0.6	<0.05	<0.005	0.035	5.20	67	3.78	0.02	0.006	<0.002		0.021	<0.05	<0.05	1.85	423	520	11.80
0.44	0.008	0.02		4	0.17	<0.01	1.2	118	<0.05	0.8	<0.05			5.70		2.68	<0.01	<0.005			0.031	<0.05	<0.05	1.45			11.85
0.43	0.013	0.03	0.2	4	<0.01	<0.01	1.4	117	<0.05	1.0	<0.05	<0.005	0.045	3.46	110	2.99	0.05	<0.005	<0.002		0.023	0.10	<0.05	1.95	480	657	12.00
0.38	0.011	0.03		4	0.03	<0.01	1.2	112	<0.05	1.0	<0.05			3.17		3.63	0.03	0.006			0.029	0.24	<0.05	2.15			11.80
0.44	<0.008	0.03		5	0.01	<0.01	1.3	130	<0.05	0.6	<0.05	<0.005	0.045	3.74	140	3.46	0.01	<0.005	<0.002		0.019	<0.05	<0.05	1.85	425	685	12.00
0.43	<0.008	0.01		4	0.03	<0.01	1.2	128	<0.05	0.6	<0.05			4.71		3.19	<0.01	<0.005			0.012	<0.05	<0.05	1.59			11.90
0.45	<0.008	0.06		5	<0.01	<0.01	1.3	136	<0.05	<0.6	<0.05	<0.005	0.040	4.93	111	2.66	<0.01	<0.005	<0.002		0.017	0.12	<0.05	1.30	285	569	11.90
0.50	<0.008	0.03	<0.2	5	0.03	<0.01	1.3	133	<0.05	<0.6	<0.05	<0.005	0.046	5.03	102	2.74	0.02	<0.005	<0.002		0.025	0.05	<0.05	1.40	310	621	11.80

SUNDANCE BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th
0	0.082	<0.05	0.008	0.945	0.290	<0.0005	48.1	0.20	14.1	<0.05	<0.02	0.013	0.06	0.6	7	27.2	<0.01	<0.2	70	<0.05	0.9	0.15	<0.005	0.005	4.09	145	0.931	0
1	0.223	<0.05	0.012	1.69	0.130	<0.0005	57.2	0.20	10.7	<0.05	<0.01	<0.005	0.11	<0.1	8	25.2	<0.01	<0.2	78	<0.05	0.8	0.15	<0.005	0.017	6.84	165	0.998	<0
2	<0.005	<0.05		2.21	0.104	<0.0005	63.9	0.20		<0.05	<0.01	<0.005	0.09		7	23.9	<0.01	<0.2	85	<0.05	0.5	<0.05			9.16		1.07	<0
3	0.084	<0.05	0.008	2.78	0.098	<0.0005	68.1	0.20	12.3	<0.05	<0.01	<0.005	0.11		7	21.7	<0.01	<0.2	87	<0.05	0.6	<0.05	<0.005	0.007	10.6	208	1.09	<0
4	0.067	<0.05		3.30	0.086	<0.0005	76.6	0.20		<0.05	<0.01	<0.005	0.08		8	20.8	<0.01	<0.2	93	<0.05	0.6	<0.05			12.8		1.14	<0
5	<0.005	<0.01	0.007	3.93	0.094	<0.0005	81.4	<0.01	13.5	<0.05	0.35	0.012	0.17	0.2	5	17.8	<0.01	<0.3	97	<0.05	0.6	<0.05	<0.005	0.005	11.2	316	1.15	0
6	<0.005	<0.01		4.38	0.083	<0.0005	77.7	0.01		<0.05	0.31	<0.008	0.11		5	15.7	<0.01	<0.3	101	<0.05	0.7	<0.05			12.4		1.10	<0
7	<0.005	<0.01	0.008	5.14	0.086	<0.0005	86.0	0.02	14.4	0.11	0.32	<0.008	0.14		6	15.8	<0.01	<0.3	105	<0.05	0.8	<0.05	<0.005	0.015	14.3	306	1.16	0
8	<0.005	<0.01		5.58	0.082	<0.0005	88.7	0.01		0.08	0.32	<0.008	0.33		5	15.2	<0.01	<0.3	110	<0.05	0.9	<0.05			14.1		1.18	0
9	<0.005	<0.01	0.009	5.66	0.081	<0.0005	97.9	0.02	14.5	0.08	0.31	<0.008	0.17		7	15.0	<0.01	0.3	114	0.05	0.6	<0.05	<0.005	0.007	17.1	347	1.21	0
10	<0.005	<0.01		5.82	0.107	<0.0005	109.	<0.01		<0.05	0.26	<0.008	<0.01		6	11.5	<0.01	<0.3	122	<0.05	<0.6	<0.05			15.3		2.04	<0
11	<0.005	<0.01	0.012	6.26	0.072	<0.0005	94.6	<0.01	16.5	<0.05	0.27	<0.008	<0.01	0.2	3	12.8	<0.01	<0.3	129	<0.05	<0.6	<0.05	<0.005	0.005	16.7	257	1.43	<0
12	<0.005	<0.01		6.42	0.077	<0.0005	98.8	<0.01		<0.05	<0.01	<0.008	<0.01		3	12.9	<0.01	<0.3	135	<0.05	<0.6	<0.05			19.1		1.37	<0
13	<0.005	<0.01	0.010	6.57	0.075	<0.0005	102.	<0.01	16.0	<0.05	0.01	<0.008	0.05		4	12.6	<0.01	0.3	135	<0.05	<0.6	<0.05	<0.005	0.005	19.4	281	1.37	0
14	<0.005	<0.01		6.77	0.073	<0.0005	101.	<0.01		<0.05	0.02	<0.008	0.02		3	11.9	<0.01	0.3	137	<0.05	<0.6	<0.05			19.6		1.33	<0
15	<0.005	<0.01	<0.005	7.10	0.084	<0.0005	108.	<0.01	14.2	<0.05	0.01	<0.008	0.02	0.2	3	12.1	<0.01	0.3	144	<0.05	<0.6	<0.05	<0.005	<0.005	20.6	289	1.38	<0
16	<0.005	<0.01		7.40	0.080	<0.0005	108.	<0.01		<0.05	0.01	<0.008	0.02		3	11.8	<0.01	0.3	146	<0.05	<0.6	<0.05			20.6		1.46	<0
17	<0.005	<0.01	0.008	7.44	0.084	<0.0005	110.	<0.01	23.0	<0.05	0.02	<0.008	0.02		3	11.6	<0.01	0.4	147	<0.05	<0.6	<0.06	<0.005	0.015	20.4	303	1.41	0
18	<0.005	<0.01		7.58	0.071	<0.0005	110.	<0.01		<0.05	0.01	<0.008	0.02		3	11.0	<0.01	0.3	144	<0.05	<0.6	<0.05			20.9		1.43	0
19	<0.005	0.05	0.011	7.76	0.080	<0.0005	116.	<0.01	14.1	<0.05	0.01	<0.008	0.02		4	11.1	<0.01	0.4	147	<0.05	<0.6	<0.05	<0.005	<0.005	21.2	225	1.44	0
20	<0.005	<0.01		7.59	0.081	<0.0005	110.	<0.01		<0.05	0.01	<0.008	0.02		3	10.2	<0.01	0.3	139	<0.05	<0.6	<0.05			19.9		1.45	0
21	<0.005	<0.01	0.010	7.39	0.069	<0.0005	116.	<0.01	13.3	<0.05	<0.01	<0.008	<0.01		1	11.2	<0.01	<0.3	125	<0.05	<0.6	<0.05	<0.005	0.002	22.2	421	1.41	<0
22	<0.005	<0.01		8.22	0.098	<0.0005	119.	0.01		<0.05	0.02	<0.008	0.07		2	11.1	<0.01	0.3	123	<0.05	<0.6	<0.05			22.5		1.44	0
23	<0.005	0.14	0.012	8.21	0.127	<0.0005	127.	0.01	16.2	<0.05	0.02	<0.008	0.08		2	11.1	<0.01	0.4	129	<0.05	<0.6	<0.05	<0.005	<0.002	24.2	455	1.51	0
24	<0.005	0.02		8.78	0.096	<0.0005	124.	<0.01		<0.05	0.02	<0.008	0.08		2	11.1	<0.01	0.5	127	<0.05	0.7	<0.05			23.3		1.46	0
25	<0.005	0.05	0.009	8.81	0.091	<0.0005	128.	<0.01	15.7	<0.05	0.02	<0.008	0.07	<0.1	3	11.3	<0.01	0.4	128	<0.05	<0.6	<0.05	<0.005	<0.002	23.6	460	1.58	0
26	<0.005	0.16		8.84	0.112	<0.0005	123.	<0.01		<0.05	<0.01	<0.008	0.13		3	10.2	<0.01	0.4	126	<0.05	<0.6	<0.05			24.2		1.51	0
27	<0.005	0.10	0.014	8.67	0.088	<0.0005	128.	<0.01	16.0	<0.05	<0.01	0.009	0.03		3	10.3	<0.01	0.4	132	<0.05	0.6	<0.05	<0.005	<0.002	26.5	570	1.55	0
28	<0.005	0.83		8.94	0.146	<0.0005	129.	<0.01		<0.05	0.01	<0.008	0.29		3	10.1	<0.01	0.4	127	<0.05	0.7	<0.05			25.8		1.47	0
29	<0.005	0.09	0.013	9.05	0.118	<0.0005	130.	<0.01	16.0	<0.05	<0.01	<0.008	0.03		3	10.2	<0.01	0.4	135	<0.05	<0.6	<0.05	<0.005	<0.002	25.8	450	1.56	0
30	<0.005	0.07	0.010	9.12	0.080	<0.0005	130.	<0.01	16.0	<0.05	<0.01	<0.008	0.04	<0.2	3	10.2	<0.01	0.5	132	<0.05	0.6	<0.05	<0.005	<0.002	25.7	475	1.52	0

SUNDANCE BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

Cr	Cu	Fe	Hg (µg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (µg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
<0.02	0.013	0.06	0.6	7	27.2	<0.01	<0.2	70	<0.05	0.9	0.15	<0.005	0.005	4.09	145	0.931	0.01	<0.005	<0.003	3.0	<0.005	0.08	<0.02	0.65	148	460	8.65
<0.01	<0.005	0.11	<0.1	8	25.2	<0.01	<0.2	78	<0.05	0.8	0.15	<0.005	0.017	6.84	165	0.998	<0.01	<0.005	<0.003	4.0	0.006	0.13	<0.02	0.62	150	542	8.30
<0.01	<0.005	0.09		7	23.9	<0.01	<0.2	85	<0.05	0.5	<0.05			9.16		1.07	<0.01	<0.005			<0.005	<0.05	<0.02	0.72			8.15
<0.01	<0.005	0.11		7	21.7	<0.01	<0.2	87	<0.05	0.6	<0.05	<0.005	0.007	10.6	208	1.09	<0.01	<0.005	<0.003		0.015	<0.05	<0.02	0.71	144	588	8.10
<0.01	<0.005	0.08		8	20.8	<0.01	<0.2	93	<0.05	0.6	<0.05			12.8		1.14	<0.01	<0.005			0.019	<0.05	<0.02	0.78			8.20
0.35	0.012	0.17	0.2	5	17.8	<0.01	<0.3	97	<0.05	0.6	<0.05	<0.005	0.005	11.2	316	1.15	0.01	<0.005	<0.003	2.1	0.041	<0.05	<0.05	0.80	144	669	8.05
0.31	<0.008	0.11		5	15.7	<0.01	<0.3	101	<0.05	0.7	<0.05			12.4		1.10	<0.01	<0.005			0.041	<0.05	<0.05	0.85			8.25
0.32	<0.008	0.14		6	15.8	<0.01	<0.3	105	<0.05	0.8	<0.05	<0.005	0.015	14.3	306	1.16	0.04	<0.005	<0.003		0.057	0.23	<0.05	0.87	142	741	8.25
0.32	<0.008	0.33		5	15.2	<0.01	<0.3	110	<0.05	0.9	<0.05			14.1		1.18	0.02	<0.005			0.062	<0.05	<0.05	0.89			8.10
0.31	<0.008	0.17		7	15.0	<0.01	0.3	114	0.05	0.6	<0.05	<0.005	0.007	17.1	347	1.21	0.04	0.005	<0.003		0.068	<0.05	<0.05	0.93	133	801	8.10
0.26	<0.008	<0.01		6	11.5	<0.01	<0.3	122	<0.05	<0.6	<0.05			15.3		2.04	<0.01	<0.005			0.033	<0.05	<0.05	0.95			8.20
0.27	<0.008	<0.01	0.2	3	12.8	<0.01	<0.3	129	<0.05	<0.6	<0.05	<0.005	0.005	16.7	257	1.43	<0.01	<0.005	<0.003	11.0	0.042	<0.05	<0.05	0.96	125	828	8.10
<0.01	<0.008	<0.01		3	12.9	<0.01	<0.3	135	<0.05	<0.6	<0.05			19.1		1.37	<0.01	<0.005			0.052	<0.05	<0.05	0.99			8.10
0.01	<0.008	0.05		4	12.6	<0.01	0.3	135	<0.05	<0.6	<0.05	<0.005	0.005	19.4	281	1.37	0.03	<0.005	<0.003		0.064	<0.05	<0.05	0.97	122	881	8.00
0.02	<0.008	0.02		3	11.9	<0.01	0.3	137	<0.05	<0.6	<0.05			19.6		1.33	<0.01	<0.005			0.060	0.10	<0.05	0.99			8.00
0.01	<0.008	0.02	0.2	3	12.1	<0.01	0.3	144	<0.05	<0.6	<0.05	<0.005	<0.005	20.6	289	1.38	<0.01	<0.005	<0.003	7.4	0.064	<0.05	<0.05	0.97	118	847	8.10
0.01	<0.008	0.02		3	11.8	<0.01	0.3	146	<0.05	<0.6	<0.05			20.6		1.46	<0.01	<0.005			0.063	0.16	<0.05	0.99			8.30
0.02	<0.008	0.02		3	11.6	<0.01	0.4	147	<0.05	<0.6	<0.06	<0.005	0.015	20.4	303	1.41	0.01	<0.005	<0.003		0.071	<0.05	<0.05	0.99	134	873	8.40
0.01	<0.008	0.02		3	11.0	<0.01	0.3	144	<0.05	<0.6	<0.05			20.9		1.43	0.01	<0.005			0.066	<0.05	<0.05	0.95			8.35
0.01	<0.008	0.02		4	11.1	<0.01	0.4	147	<0.05	<0.6	<0.05	<0.005	<0.005	21.2	225	1.44	0.04	<0.005	<0.002		0.071	<0.05	<0.05	1.00	120	905	8.35
0.01	<0.008	0.02		3	10.2	<0.01	0.3	139	<0.05	<0.6	<0.05			19.9		1.45	0.02	<0.005			0.066	<0.05	<0.05	0.93			8.30
<0.01	<0.008	<0.01		1	11.2	<0.01	<0.3	125	<0.05	<0.6	<0.05	<0.005	0.002	22.2	421	1.41	<0.01	<0.005	<0.002		<0.005	<0.05	<0.05	0.97	122	896	8.30
0.02	<0.008	0.07		2	11.1	<0.01	0.3	123	<0.05	<0.6	<0.05			22.5		1.44	0.03	<0.005			0.072	<0.05	<0.05	0.90			8.25
0.02	<0.008	0.08		2	11.1	<0.01	0.4	129	<0.05	<0.6	<0.05	<0.005	<0.002	24.2	455	1.51	0.03	<0.005	<0.002		0.071	0.06	<0.05	0.94	120	913	8.25
0.02	<0.008	0.08		2	11.1	<0.01	0.5	127	<0.05	0.7	<0.05			23.3		1.46	0.04	<0.005			0.078	<0.05	<0.05	1.01			8.30
0.02	<0.008	0.07	<0.1	3	11.3	<0.01	0.4	128	<0.05	<0.6	<0.05	<0.005	<0.002	23.6	460	1.58	0.02	<0.005	<0.002		0.081	0.08	<0.05	1.01	125	937	8.30
<0.01	<0.008	0.13		3	10.2	<0.01	0.4	126	<0.05	<0.6	<0.05			24.2		1.51	0.02	0.006			0.078	0.20	<0.05	1.05			8.25
<0.01	0.009	0.03		3	10.3	<0.01	0.4	132	<0.05	0.6	<0.05	<0.005	<0.002	26.5	520	1.55	0.04	<0.005	<0.002		0.073	<0.05	<0.05	1.01	116	990	8.10
0.01	<0.008	0.29		3	10.1	<0.01	0.4	127	<0.05	0.7	<0.05			25.8		1.47	0.01	0.033			0.069	0.05	<0.05	1.02			8.10
<0.01	<0.008	0.03		3	10.2	<0.01	0.4	135	<0.05	<0.6	<0.05	<0.005	<0.002	25.8	450	1.56	0.02	<0.005	<0.002		0.069	<0.05	<0.05	1.00	130	960	8.20
<0.01	<0.008	0.04	<0.2	3	10.2	<0.01	0.5	132	<0.05	0.6	<0.05	<0.005	<0.002	25.7	475	1.52	0.02	<0.005	<0.002		0.071	<0.05	<0.05	0.96	116	1 020	8.30

LAKEVIEW FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr
0	<0.005	<0.01	<0.002	0.031	0.143	<0.0005	38.8	<0.01	30	<0.05	<0.01	0.009	0.05	0.1	5	8.23	<0.01	<0.3	15	<0.05	<0.6	<0.05	<0.003	<0.003	<0.05	21	0.158
1	<0.005	6.22	0.015	7.89	0.217	<0.0005	241.	<0.01	24	<0.05	0.05	<0.008	0.02	0.1	13	8.74	<0.01	0.3	31	<0.05	<0.6	<0.05	0.008	0.027	<0.05	490	3.03
2	<0.005	7.01	0.023	14.0	0.189	<0.0005	464.	<0.01	28	<0.05	0.12	<0.008	0.05	0.1	24	2.21	<0.01	0.6	49	<0.05	<0.6	<0.05	0.005	0.030	<0.05	930	5.42
3	<0.005	11.9	0.046	17.8	0.142	<0.0005	634.	<0.01	27	<0.05	0.14	<0.008	0.04	0.6	36	9.27	<0.01	0.7	64	<0.05	<0.6	<0.05	<0.003	0.005	<0.05	190	8.16
4	<0.005	12.3	0.015	23.9	0.118	<0.0005	814.	<0.01	30	0.05	0.15	0.009	0.05	<0.1	47	1.04	<0.01	1.1	80	<0.05	0.6	<0.05	0.005	0.044	<0.05	2 120	10.4
5	<0.005	10.6	0.006	31.9	0.116	<0.0005	908.	<0.01	33	<0.05	0.15	<0.008	0.08	<0.1	53	1.66	<0.01	1.2	107	<0.05	0.6	<0.05	0.005	0.040	<0.05	2 060	11.5
6	<0.005	10.3	0.005	23.4	0.113	<0.0005	857.	<0.01	30	0.06	0.24	0.015	0.07	<0.1	62	2.54	<0.01	1.5	102	0.06	1.1	<0.05	0.006	0.040	<0.05	2 210	11.9
7	<0.005	10.0	0.006	25.5	0.116	<0.0005	878.	<0.01	30	<0.05	0.22	0.018	0.10	0.2	74	2.86	<0.01	1.6	135	<0.05	1.1	<0.05	0.008	0.042	<0.05	810	14.4
8	<0.005	11.1	0.008	27.2	0.133	<0.0005	985.	<0.01	38	0.27	0.23	0.036	0.09	<0.1	88	3.70	<0.01	2.5	158	<0.05	0.8	<0.05	0.008	0.058	<0.05	1 310	16.5
9	<0.005	9.65	0.004	28.8	0.127	<0.0005	840.	<0.01	47	0.12	0.23	0.015	0.09	<0.1	105	1.69	<0.01	2.6	176	<0.05	0.9	<0.05	0.005	0.048	<0.05	1 590	17.5
10	<0.005	10.1	0.007	25.9	0.083	<0.0005	908.	<0.01	38	0.06	0.20	<0.008	0.09	<0.1	98	1.41	<0.01	1.9	159	<0.05	1.0	<0.05	0.005	0.075	<0.05	1 260	15.6
11	<0.005	11.1	0.010	26.3	0.102	<0.0005	809.	<0.01	41	<0.05	0.26	<0.008	0.09		115	1.48	<0.01	2.2	188	<0.05	1.0	<0.05	0.005	0.062	<0.05	1 920	18.3
12	<0.005	10.0	0.028	21.4	0.121	<0.0005	847.	<0.01	44	<0.05	0.29	0.014	0.07		129	2.29	<0.01	2.9	208	<0.05	0.9	<0.05	0.005	0.085	<0.05	2 160	20.6
13	<0.005	5.74	0.010	21.0	0.142	<0.0005	739.	<0.01	46	0.12	0.30	0.028	0.16		121	1.59	<0.01	2.5	193	<0.05	1.0	<0.05	0.005	0.088	<0.05	2 170	16.5
14	<0.005	6.88	0.008	40.9	0.071	<0.0005	808.	<0.01	45	<0.05	0.29	0.014	0.09		136	1.61	<0.01	2.7	204	<0.05	0.8	<0.05		0.072	<0.05	1 970	19.4
15	<0.005	7.28		40.8	0.080	<0.0005	773.	0.01	35	0.14	0.30	0.016	0.11	<0.2	140	1.60	<0.01	2.9	208	0.07	0.8	<0.05	0.003		<0.05	1 370	18.6
16	<0.005	7.06		42.8	0.092	<0.0005	817.	<0.01	51	<0.05	0.34	<0.008	0.06		169	1.87	<0.01	3.3	270	<0.05	0.8	<0.05	0.003		<0.05	1 640	19.7
17	<0.005	6.87		42.8	0.107	<0.0005	815.	0.01	45	0.12	0.38	0.018	0.12		173	1.78	<0.01	3.6	270	0.05	0.8	<0.05			<0.05	2 100	19.5
18	<0.005	6.14		42.7	0.115	<0.0005	779.	<0.01	51	<0.05	0.39	<0.008	<0.01	<0.2	174	2.43	<0.01	4.1	257	<0.05	0.8	<0.05	0.003		<0.05	2 190	15.8
19	<0.005	4.97		47.3	0.102	<0.0005	772.	<0.01	45	0.22	0.38	0.019	0.12		168	1.91	<0.01	3.5	274	0.07	1.0	<0.05			<0.05	2 390	14.6
20	<0.005	4.74		56.4	0.112	<0.0005	790.	0.02	59	<0.05	0.41	0.016	0.13	<0.1	190	3.81	<0.01	4.3	308	0.07	0.9	<0.05	0.003		<0.05	2 400	17.3

LAKEVIEW FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
.05	<0.01	0.009	0.05	0.1	5	8.23	<0.01	<0.3	15	<0.05	<0.6	<0.05	<0.003	<0.003	<0.05	21	0.158	0.02	<0.005	0.004	1.6	<0.005	0.11	<0.05	0.30	100	200	7.30
.05	0.05	<0.008	0.02	0.1	13	8.74	<0.01	0.3	31	<0.05	<0.6	<0.05	0.008	0.027	<0.05	490	3.03	0.11	<0.005	0.009	3.6	0.116	<0.05	<0.05	1.25	96	1 190	9.30
.05	0.12	<0.008	0.05	0.1	24	2.21	<0.01	0.6	49	<0.05	<0.6	<0.05	0.005	0.030	<0.05	930	5.42	0.15	<0.005	0.009		0.121	<0.05	<0.05	1.95	120	1 940	9.60
.05	0.14	<0.008	0.04	0.6	36	9.77	<0.01	0.7	64	<0.05	<0.6	<0.05	<0.003	0.005	<0.05	190	8.16	0.21	<0.005	0.009		0.142	<0.05	<0.05	2.60	170	2 770	9.85
.05	0.15	0.009	0.05	<0.1	47	1.04	<0.01	1.1	80	<0.05	0.6	<0.05	0.005	0.044	<0.05	2 120	10.4	<0.01	<0.005	0.009		0.143	<0.05	<0.05	3.00	200	3 410	9.80
.05	0.15	<0.008	0.08	<0.1	53	1.66	<0.01	1.2	107	<0.05	0.6	<0.05	0.005	0.040	<0.05	2 060	11.5	<0.01	<0.005	0.007		0.130	<0.05	<0.05	3.45	200	3 890	9.60
.06	0.24	0.015	0.07	<0.1	62	2.54	<0.01	1.5	102	0.06	1.1	<0.05	0.006	0.040	<0.05	2 210	11.9	<0.01	<0.005	0.007		0.141	<0.05	<0.05	3.80	188	4 160	9.55
.05	0.22	0.018	0.10	0.2	74	2.86	<0.01	1.6	135	<0.05	1.1	<0.05	0.008	0.042	<0.05	810	14.4	<0.01	<0.005	0.004		0.122	<0.05	<0.05	3.45	200	4 030	9.70
.27	0.23	0.036	0.09	<0.1	88	3.70	<0.01	2.5	158	<0.05	0.8	<0.05	0.008	0.058	<0.05	1 310	16.5	<0.01	0.007	0.006		0.187	<0.05	<0.05	3.80	218	4 860	9.90
.12	0.23	0.015	0.09	<0.1	105	1.69	<0.01	2.6	176	<0.05	0.9	<0.05	0.005	0.048	<0.05	1 590	17.5	<0.01	<0.005	0.008		0.166	0.56	<0.05	3.60	204	3 780	9.75
.06	0.20	<0.008	0.09	<0.1	98	1.41	<0.01	1.9	159	<0.05	1.0	<0.05	0.005	0.075	<0.05	1 260	15.6	<0.01	0.009	0.008		0.131	<0.05	<0.05		196	4 170	
.05	0.26	<0.008	0.09		115	1.48	<0.01	2.2	188	<0.05	1.0	<0.05	0.005	0.062	<0.05	1 920	18.3	<0.01	0.007	0.008	0.4	0.145	<0.05	<0.05	4.05	220	3 860	9.75
05	0.29	0.014	0.07		129	2.29	<0.01	2.9	208	<0.05	0.9	<0.05	0.005	0.085	<0.05	2 160	20.6	<0.01	<0.005	0.008		0.137	0.15	<0.05	4.20	188	4 320	9.55
12	0.30	0.028	0.16		121	1.59	<0.01	2.5	193	<0.05	1.0	<0.05	0.005	0.088	<0.05	2 170	16.5	<0.01	0.008	0.008		0.113	0.12	<0.05	4.25	144	3 960	9.50
05	0.29	0.014	0.09		136	1.61	<0.01	2.7	204	<0.05	0.8	<0.05		0.072	<0.05	1 970	19.4	<0.01	<0.005	0.009		0.146	<0.05	<0.05	4.35	204	4 200	9.30
14	0.30	0.016	0.11	<0.2	140	1.60	<0.01	2.9	208	0.07	0.8	<0.05	0.003		<0.05	1 370	18.6	<0.01	0.007	0.007		0.151	<0.05	<0.05	4.00	216	4 020	9.50
05	0.34	<0.008	0.06		169	1.87	<0.01	3.3	270	<0.05	0.8	<0.05	0.003		<0.05	1 640	19.7	<0.01	<0.005	0.008	0.4	0.140	<0.05	<0.05	4.30	230	4 320	9.50
12	0.38	0.018	0.12		173	1.78	<0.01	3.6	270	0.05	0.8	<0.05			<0.05	2 100	19.5	0.02	<0.005	0.007		0.169	<0.05	<0.05	4.40	216	4 120	9.45
05	0.39	<0.008	<0.01	<0.2	174	2.43	<0.01	4.1	257	<0.05	0.8	<0.05	0.003		<0.05	2 190	15.8	<0.01	<0.005	0.011		0.127	<0.05	<0.05	4.45	204	4 230	9.25
22	0.38	0.019	0.12		168	1.91	<0.01	3.5	274	0.07	1.0	<0.05			<0.05	2 390	14.6	0.05	0.005	0.009		0.165	<0.05	<0.05	4.50	222	4 220	9.40
05	0.41	0.016	0.13	<0.1	190	3.81	<0.01	4.3	308	0.07	0.9	<0.05	0.003		<0.05	2 400	17.3	0.07	<0.005	0.005	1.5	0.127	<0.05	<0.05	4.50	212	4 450	9.10

LAKEVIEW BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr
0	<0.005	< 0.01	<0.002	0.031	0.143	<0.0005	38.8	<0.01	30	<0.05	<0.01	0.009	0.05	0.1	5	8.23	<0.01	<0.3	15	<0.05	<0.6	<0.05	<0.003	<0.003	<0.05	21	0.158
1	<0.005	< 0.01	0.005	0.082	0.069	<0.0005	61.2	<0.01	31	<0.05	<0.01	<0.008	<0.01	0.1	1	8.35	<0.01	<0.3	14	<0.05	<0.6	<0.05	<0.003	<0.003	0.42	54	0.288
2	<0.005	< 0.01	0.023	0.123	0.078	<0.0005	90.6	<0.01	29	<0.05	<0.01	<0.008	<0.01	0.1	<1	9.05	0.01	<0.3	16	<0.05	<0.6	<0.05	<0.003	<0.003	0.99	23	0.434
3	<0.005	< 0.01	0.060	0.214	0.062	<0.0005	112.	<0.01	27	<0.05	<0.01	<0.008	0.02	0.2	2	9.27	0.02	<0.3	15	<0.05	<0.6	<0.05	0.005	0.044	1.45	190	0.550
4	<0.005	0.02	0.017	0.276	0.062	<0.0005	139.	<0.01	23	<0.05	<0.01	<0.008	0.05	<0.1	3	10.1	0.04	<0.3	14	<0.05	<0.6	<0.05	<0.003	0.004	2.69	280	0.722
5	<0.005	< 0.01	0.006	0.325	0.050	<0.0005	175.	<0.01	32	<0.05	<0.01	<0.008	0.02	<0.1	2	10.6	0.07	<0.3	15	<0.05	<0.6	<0.05	<0.003	0.004	3.47	370	0.815
6	<0.005	< 0.01	0.008	0.433	0.047	<0.0005	187.	<0.01	20	0.06	0.10	0.013	0.03	<0.1	3	11.1	0.10	<0.3	15	0.07	0.6	<0.05	<0.003	0.004	3.62	500	0.913
7	<0.005	< 0.01	0.003	0.497	0.038	<0.0005	231.	<0.01	12	<0.05	0.08	0.010	0.03	0.2	3	12.3	0.14	<0.3	14	0.05	<0.6	<0.05	0.008	0.005	3.90	540	1.19
8	<0.005	0.45	0.004	0.430	0.039	<0.0005	260.	<0.01	31	0.14	<0.01	0.030	0.04	<0.1	4	13.5	0.19	0.4	17	0.05	<0.6	<0.05	<0.003	0.005	5.26	540	1.42
9	<0.005	0.54	0.003	0.510	0.055	<0.0005	309.	<0.01	37	0.15	<0.01	0.021	0.11	<0.1	4	15.1	0.30	0.4	24	0.07	<0.6	<0.05	<0.003	0.005	6.20	850	1.74
10	<0.005	0.55	0.003	0.499	0.043	<0.0005	321.	<0.01	48	<0.05	<0.01	<0.008	<0.01	<0.1	2	15.6	0.39	<0.3	21	0.09	<0.6	<0.05	<0.003	0.015	6.62	920	1.65
11	<0.005	1.67	0.003	0.555	0.030	<0.0005	378.	<0.01	48	<0.05	<0.01	<0.008	0.13		3	15.5	0.57	<0.3	15	0.07	<0.6	<0.05	<0.003	0.010	7.70	920	1.93
12	<0.005	2.47	0.031	0.468	0.041	<0.0005	405.	<0.01	40	0.12	<0.01	0.037	0.17		6	17.3	0.76	0.3	17	0.13	<0.6	<0.05	<0.003	0.010	9.91	910	2.23
13	<0.005	2.70	0.006	0.475	0.030	<0.0005	414.	<0.01	42	0.16	<0.01	0.041	0.20		7	16.6	0.83	0.3	15	0.14	0.6	<0.05	<0.003	0.010	9.86	1 040	2.07
14	<0.005	2.74	0.002	1.03	0.024	<0.0005	462.	<0.01	25	0.09	0.01	0.034	0.10		5	19.2	1.04	<0.3	16	0.18	<0.6	<0.05		0.010	11.9	1 300	2.21
15	<0.005	4.16		1.19	0.023	<0.0005	514.	<0.01	53	<0.05	<0.01	0.036	0.12	<0.2	4	21.4	1.34	<0.3	17	0.20	<0.6	<0.05	<0.003		14.8	2 040	2.72
16	<0.005	5.12		1.30	0.021	<0.0005	528.	<0.01	36	<0.05	<0.01	0.039	0.09		4	21.9	1.48	<0.3	23	0.20	<0.6	<0.05	<0.003		15.4	1 350	2.84
17	<0.005	5.81		1.44	0.024	<0.0005	615.	0.01	34	0.23	0.03	0.059	0.22		7	25.4	1.86	0.3	18	0.28	<0.6	<0.05			17.9	1 270	3.02
18	<0.005	7.51		1.57	0.013	<0.0005	626.	<0.01	22	0.17	<0.01	0.056	0.16	<0.2	6	26.6	2.06	<0.3	19	0.29	<0.6	<0.05	0.003		20.0	1 470	3.23
19	<0.005	9.66		1.77	0.018	<0.0005	626.	<0.01	21	<0.05	<0.01	0.058	0.13		5	28.6	2.35	<0.3	20	0.29	<0.6	<0.05			21.4	1 490	3.47
20	<0.005	10.4		1.79	0.026	0.0012	601.	0.02	31	0.19	0.07	0.076	0.18	<0.1	5	28.4	2.54	0.3	19	0.36	0.6	<0.05	<0.003		21.9	1 680	3.54

LAKEVIEW BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
05	<0.01	0.009	0.05	0.1	5	8.23	<0.01	<0.3	15	<0.05	<0.6	<0.05	<0.003	<0.003	<0.05	21	0.158	0.07	<0.005	0.004	1.6	<0.005	0.11	<0.05	0.30	100	200	7.30
05	<0.01	<0.008	<0.01	0.1	1	8.35	<0.01	<0.3	14	<0.05	<0.6	<0.05	<0.003	<0.003	0.42	54	0.288	0.02	<0.005	0.007	1.0	<0.005	<0.05	<0.05	0.45	104	200	8.30
05	<0.01	<0.008	<0.01	0.1	<1	9.05	0.01	<0.3	16	<0.05	<0.6	<0.05	<0.003	<0.003	0.99	23	0.434	<0.01	<0.005	0.009		<0.005	<0.05	<0.05	0.55	88	380	8.10
05	<0.01	<0.008	0.02	0.2	2	9.27	0.02	<0.3	15	<0.05	<0.6	<0.05	0.005	0.044	1.45	190	0.550	0.08	<0.005	0.009		<0.005	0.12	<0.05	0.65	82	490	7.80
05	<0.01	<0.008	0.05	<0.1	3	10.1	0.04	<0.3	14	<0.05	<0.6	<0.05	<0.003	0.004	2.69	280	0.722	<0.01	<0.005	0.009		<0.005	0.06	<0.05	0.75	68	620	8.00
05	<0.01	<0.008	0.02	<0.1	2	10.6	0.07	<0.3	15	<0.05	<0.6	<0.05	<0.003	0.004	3.47	370	0.815	<0.01	<0.005	0.007		<0.005	<0.05	<0.05	0.91	60	740	7.90
06	0.10	0.013	0.03	<0.1	3	11.1	0.10	<0.3	15	0.07	0.6	<0.05	<0.003	0.004	3.62	500	0.913	0.01	<0.005	0.009		<0.005	<0.05	<0.05	1.05	46	860	7.60
05	0.08	0.010	0.03	0.2	3	12.3	0.14	<0.3	14	0.05	<0.6	<0.05	0.008	0.005	3.90	540	1.19	<0.01	<0.005	0.005		<0.005	<0.05	<0.05	1.08			7.60
14	<0.01	0.030	0.04	<0.1	4	13.5	0.19	0.4	17	0.05	<0.6	<0.05	<0.003	0.005	5.26	540	1.42	0.07	<0.005	0.005		0.015	<0.05	<0.05	1.30	24	1 370	7.50
15	<0.01	0.021	0.11	<0.1	4	15.1	0.30	0.4	24	0.07	<0.6	<0.05	<0.003	0.005	6.20	850	1.74	0.09	<0.005	0.010		0.015	0.08	<0.05	1.35	15	1 240	6.90
05	<0.01	<0.008	<0.01	<0.1	2	15.6	0.39	<0.3	21	0.09	<0.6	<0.05	<0.003	0.015	6.62	920	1.65	<0.01	<0.005	0.009		<0.005	0.13	<0.05	1.50	<1	1 400	5.70
05	<0.01	<0.008	0.13		3	15.5	0.57	<0.3	15	0.07	<0.6	<0.05	<0.003	0.010	7.70	920	1.93	<0.01	0.009	0.009	0.6	<0.005	<0.05	<0.05	1.65	<1	1 490	4.90
2	<0.01	0.037	0.17		6	17.3	0.76	0.3	17	0.13	<0.6	<0.05	<0.003	0.010	9.91	910	2.23	0.08	0.006	0.010		0.006	0.39	<0.05	1.85	<1	1 720	4.80
6	<0.01	0.041	0.20		7	16.6	0.83	0.3	15	0.14	0.6	<0.05	<0.003	0.010	9.86	1 040	2.07	0.03	0.014	0.008		0.007	0.41	<0.05	2.20	5	1 810	4.70
9	0.01	0.034	0.10		5	19.2	1.04	<0.3	16	0.18	<0.6	<0.05		0.010	11.9	1 300	2.21	0.04	<0.005	0.009		0.021	0.15	<0.05	2.20	<1	2 050	4.50
5	<0.01	0.036	0.12	<0.2	4	21.4	1.34	<0.3	17	0.20	<0.6	<0.05	<0.003		14.8	2 040	2.72	<0.01	<0.005	0.016		0.008	0.21	<0.05	2.20	<1	2 120	4.50
5	<0.01	0.039	0.09		4	21.9	1.48	<0.3	23	0.20	<0.6	<0.05	<0.003		15.4	1 350	2.84	<0.01	<0.005	0.013	<0.2	<0.005	0.25	<0.05	2.30	3	2 290	4.10
3	0.03	0.059	0.22		7	25.4	1.86	0.3	18	0.28	<0.6	<0.05			17.9	1 270	3.07	0.11	0.011	0.012		0.034	0.84	<0.05	2.70	<1	2 390	4.65
7	<0.01	0.056	0.16	<0.2	6	26.6	2.06	<0.3	19	0.29	<0.6	<0.05	0.003		20.0	1 470	3.23	0.03	<0.005	0.005		0.022	0.35	<0.05	2.75	<1	2 510	4.45
5	<0.01	0.058	0.13		5	28.6	2.35	<0.3	20	0.29	<0.6	<0.05			21.4	1 490	3.47	<0.01	<0.005	0.014		<0.005	1.03	<0.05	2.70	4	2 580	4.45
9	0.07	0.076	0.18	<0.1	5	28.4	2.54	0.3	19	0.36	0.6	<0.05	<0.003		21.9	1 680	3.54	0.12	<0.005	0.008	<0.2	0.047	0.44	<0.05	2.79	4	2 650	4.40

NANTICOKE FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr
0	<0.005	<0.01	0.058	0.113	0.096	<0.0005	59.7	<0.01	41	<0.05	<0.01	<0.008	0.01	0.2	13	9.60	<0.01	<0.3	54	<0.05	<0.6	<0.05	0.005	0.022	0.30	810	0.284
1	<0.005	0.76	0.017	3.06	0.581	<0.0005	405.	<0.01	78	<0.05	<0.01	<0.008	0.04	0.1	14	0.07	<0.01	<0.3	56	<0.05	<0.6	<0.05	<0.003	0.012	0.88	180	1.96
2	<0.005	0.35	0.035	3.45	0.505	<0.0005	507.	<0.01	69	<0.05	<0.01	<0.008	0.03	0.2	16	0.02	<0.01	0.3	63	<0.05	<0.6	<0.05	<0.003	0.023	0.07	250	4.06
3	<0.005	0.22	0.066	4.15	0.347	<0.0005	805.	<0.01	47	<0.05	<0.01	0.008	0.05	0.2	18	<0.01	<0.01	0.4	68	<0.05	0.6	<0.05	0.005	0.035	<0.05	300	7.62
4	<0.005	0.08	0.030	5.39	0.393	<0.0005	1 030.	<0.01	58	<0.05	0.01	0.009	0.09	<0.1	17	<0.01	<0.01	0.6	62	<0.05	0.7	<0.05	0.005	0.035	<0.05	380	10.3
5	<0.005	<0.01	0.010	5.72	0.360	<0.0005	1 070.	<0.01	71	<0.05	<0.01	0.014	0.08	<0.1	19	<0.01	<0.01	0.8	202	<0.05	0.6	<0.05	<0.006	0.035	<0.05	580	10.7
6	<0.005	<0.01	0.012	3.76	0.324	<0.0005	1 080.	<0.01	68	<0.05	0.07	0.021	0.08	<0.1	24	<0.01	<0.01	1.0	115	0.08	1.2	<0.05	0.006	0.036	<0.05	720	14.2
7	<0.005	<0.01	0.036	4.81	0.284	<0.0005	1 060.	0.01	76	<0.05	0.09	0.010	0.12	<0.1	25	0.03	<0.01	1.1	80	<0.05	1.2	<0.05	0.008	0.040	<0.05	940	17.5
8	<0.005	1.34	0.016	4.47	0.300	<0.0005	1 090.	<0.01	74	0.05	0.07	0.022	0.07	<0.1	26	<0.01	<0.01	1.5	88	<0.05	0.7	<0.05	0.008	0.040	<0.05	690	20.7
9	<0.005	1.41	0.009	4.42	0.338	<0.0005	1 130.	<0.01	81	0.19	0.09	0.027	0.09	<0.1	32	0.05	<0.01	2.1	107	<0.05	0.9	<0.05	0.005	0.032	<0.05	810	24.2
10	<0.005	0.69	0.005	2.62	0.174	<0.0005	1 070.	<0.01	72	<0.05	0.06	<0.008	0.04	<0.1	25	0.04	<0.01	0.9	187	<0.05	0.9	<0.05	0.005	0.024	<0.05	840	18.2
11	<0.005	0.87	0.004	2.76	0.185	<0.0005	1 100.	<0.01	67	<0.05	0.09	<0.008	0.04		28	<0.01	<0.01	1.1	95	<0.05	0.9	<0.05	0.006	0.030	<0.05	760	31.5
12	<0.005	0.90	0.008	2.11	0.267	<0.0005	986.	<0.01	97	<0.05	0.13	0.014	0.06		37	0.06	<0.01	1.9	111	<0.05	0.9	<0.05	0.007	0.032	<0.05	740	29.5
13	<0.005	0.84	0.008	1.79	0.243	<0.0005	953.	<0.01	96	0.09	0.15	0.027	0.09		37	<0.01	<0.01	1.7	106	<0.05	1.0	<0.05	0.005	0.033	<0.05	720	31.1
14	<0.005	0.39	0.003	3.31	0.197	<0.0005	890.	<0.01	81	0.05	0.15	0.014	0.10		39	<0.01	<0.01	2.0	109	<0.05	0.8	<0.05		0.023	0.08	800	30.6
15	<0.005	0.35		3.73	0.277	<0.0005	897.	<0.01	81	<0.05	0.19	<0.008	0.10	<0.2	46	0.18	<0.01	2.2	140	<0.05	0.7	<0.05	<0.003		0.07	940	31.2
16	<0.005	0.39		3.20	0.262	<0.0005	815.	<0.01	86	<0.05	0.22	<0.008	0.07		48	0.03	<0.01	2.4	134	<0.05	0.8	<0.05	<0.003		0.17	1 030	30.5
17	<0.005	0.64		3.37	0.282	<0.0005	763.	0.01	92	0.08	0.28	0.014	0.09		52	<0.01	<0.01	3.0	145	<0.05	0.8	<0.05			0.36	1 050	29.6
18	<0.005	0.63		3.00	0.232	<0.0005	692.	0.01	70	0.24	0.31	0.020	0.13	<0.2	52	0.04	<0.01	3.0	145	0.06	0.9	<0.05			0.61	650	23.7
19	<0.005	0.60		3.31	0.226	<0.0005	670.	0.01	78	0.22	0.38	0.020	0.11		54	<0.01	<0.01	3.2	141	0.06	0.9	<0.05			0.56	720	22.7
20	<0.005	0.95		3.47	0.267	<0.0005	563.	0.02	78	<0.05	0.41	0.012	0.08	<0.1	54	0.03	<0.01	3.5	153	0.06	0.8	<0.05	<0.003		0.91	800	22.9

NANTICOKE FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
<0.05	<0.01	<0.008	0.01	0.2	13	9.60	<0.01	<0.3	54	<0.05	<0.6	<0.05	0.005	0.022	0.30	810	0.284	0.03	<0.005	0.007	2.8	<0.005	<0.05	<0.05	0.63	94		7.80
<0.05	<0.01	<0.008	0.04	0.1	14	0.07	<0.01	<0.3	56	<0.05	<0.6	<0.05	<0.003	0.012	0.88	180	1.96	0.23	<0.005	0.009	1.8	0.010	<0.05	<0.05	3.40	852	1 100	12.10
<0.05	<0.01	<0.008	0.03	0.2	16	0.02	<0.01	0.3	63	<0.05	<0.6	<0.05	<0.003	0.023	0.07	250	4.06	0.19	<0.005	0.010		<0.005	<0.05	<0.05	4.50	1 100	1 740	12.00
<0.05	<0.01	0.008	0.05	0.2	18	<0.01	<0.01	0.4	68	<0.05	0.6	<0.05	0.005	0.035	<0.05	300	7.62	0.27	<0.005	0.010		<0.005	<0.05	<0.05	7.10	1 700	2 250	12.10
<0.05	0.01	0.009	0.09	<0.1	17	<0.01	<0.01	0.6	62	<0.05	0.7	<0.05	0.005	0.035	<0.05	380	10.3	<0.01	<0.005	0.009		<0.005	<0.05	<0.05	8.50	1 920	2 700	12.20
<0.05	<0.01	0.014	0.08	<0.1	19	<0.01	<0.01	0.8	202	<0.05	0.6	<0.05	<0.006	0.035	<0.05	580	10.7	<0.01	<0.005	0.007		<0.005	<0.05	<0.05	8.25	2 030	2 890	12.30
<0.05	0.07	0.021	0.08	<0.1	24	<0.01	<0.01	1.0	115	0.08	1.2	<0.05	0.006	0.036	<0.05	720	14.2	<0.01	<0.005	0.009		<0.005	<0.05	<0.05	9.30	2 190	3 060	12.10
<0.05	0.09	0.010	0.12	<0.1	25	0.03	<0.01	1.1	80	<0.05	1.2	<0.05	0.008	0.040	<0.05	940	17.5	<0.01	0.008	0.009		<0.005	<0.05	<0.05	8.80	2 010	3 150	12.30
0.05	0.07	0.022	0.07	<0.1	26	<0.01	<0.01	1.5	88	<0.05	0.7	<0.05	0.008	0.040	<0.05	690	20.7	<0.01	<0.005	0.009		<0.005	<0.05	<0.05	9.20	1 990	3 250	12.30
0.19	0.09	0.027	0.09	<0.1	32	0.05	<0.01	2.1	107	<0.05	0.9	<0.05	0.005	0.032	<0.05	810	24.2	<0.01	<0.005	0.008		0.020	<0.05	<0.05	9.75	2 030	3 110	12.35
<0.05	0.06	<0.008	0.04	<0.1	25	0.04	<0.01	0.9	187	<0.05	0.9	<0.05	0.005	0.024	<0.05	840	18.2	<0.01	<0.005	0.005		<0.005	<0.05	<0.05		2 020	3 080	
<0.05	0.09	<0.008	0.04		28	<0.01	<0.01	1.1	95	<0.05	0.9	<0.05	0.006	0.030	<0.05	760	31.5	<0.01	<0.005	0.009	0.2	<0.005	<0.05	<0.05	9.30	1 910	3 170	12.30
<0.05	0.13	0.014	0.06		37	0.06	<0.01	1.9	111	<0.05	0.9	<0.05	0.007	0.032	<0.05	740	29.5	<0.01	<0.005	0.010		<0.005	<0.05	<0.05	9.20	1 810	3 050	12.25
0.09	0.15	0.027	0.09		37	<0.01	<0.01	1.7	106	<0.05	1.0	<0.05	0.005	0.033	<0.05	720	31.1	<0.01	0.005	0.005		<0.005	<0.05	<0.05	9.50	1 660	2 990	12.20
0.05	0.15	0.014	0.10		39	<0.01	<0.01	2.0	109	<0.05	0.8	<0.05		0.023	0.08	800	30.6	<0.01	<0.005	0.010		<0.005	<0.05	<0.05	8.30	1 520	2 880	12.15
<0.05	0.19	<0.008	0.10	<0.2	46	0.18	<0.01	2.2	140	<0.05	0.7	<0.05	<0.003		0.07	940	31.2	<0.01	<0.005	0.017		<0.005	0.44	<0.05	8.00	1 530	2 850	12.10
<0.05	0.22	<0.008	0.07		48	0.03	<0.01	2.4	134	<0.05	0.8	<0.05	<0.003		0.17	1 030	30.5	<0.01	<0.005	0.016	<0.2	<0.005	0.17	<0.05	7.30	1 590	3 790	12.00
0.08	0.28	0.014	0.09		52	<0.01	<0.01	3.0	145	<0.05	0.8	<0.05			0.36	1 050	29.6	<0.01	<0.005	0.017		0.013	<0.05	<0.05	7.10	1 220	2 650	12.05
0.24	0.31	0.020	0.13	<0.2	52	0.04	<0.01	3.0	145	0.06	0.9	<0.05			0.61	650	23.7	0.07	0.008	0.022		0.045	<0.05	<0.05	6.50	1 010	2 440	11.90
0.22	0.38	0.020	0.11		54	<0.01	<0.01	3.2	141	0.06	0.9	<0.05			0.56	720	22.7	0.06	0.007	0.016		0.044	<0.05	<0.05	6.10	770	2 420	11.90
<0.05	0.41	0.012	0.08	<0.1	54	0.03	<0.01	3.5	153	0.06	0.8	<0.05	<0.003		0.91	800	22.9	0.03	<0.005	0.007	<0.2	0.015	<0.05	<0.05	5.40		2 300	11.95

NANTICOKE BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th
0	<0.005	<0.01	0.058	0.113	0.096	<0.0005	59.7	<0.01	41	<0.05	<0.01	<0.008	0.01	0.2	13	9.60	<0.01	<0.3	54	<0.05	<0.6	<0.05	0.005	0.022	0.30	810	0.284	0.0
1	<0.005	<0.01	0.035	0.192	0.138	<0.0005	65.4	<0.01	72	<0.05	0.05		0.04	1.2	13	9.75	<0.01	<0.3	52	<0.05	<0.6	<0.05	<0.003	<0.003	1.03	81	0.351	0.0
2	<0.005	<0.01	0.084	0.215	0.078	<0.0005	71.9	<0.01	69	0.09	<0.01	<0.008	0.02	0.4	13	9.75	<0.01	<0.3	49	<0.05	<0.6	<0.05	<0.003	<0.003	1.46	96	0.407	0.1
3	<0.005	<0.01	0.113	0.231	0.075	<0.0005	81.6	<0.01	68	<0.05	<0.01	<0.008	0.01	0.3	13	10.6	<0.01	<0.3	52	<0.05	<0.6	<0.05	<0.003	<0.003	1.92	130	0.471	0.0
4	<0.005	<0.01	0.029	0.301	0.078	<0.0005	87.9	<0.01	68	<0.05	<0.01	<0.008	0.05	<0.1	12	11.1	<0.01	<0.3	48	<0.05	<0.6	<0.05	<0.003	<0.003	2.88	210	0.600	0.6
5	<0.005	<0.01	0.012	0.322	0.067	<0.0005	99.9	<0.01	71	<0.05	<0.01	<0.008	0.02	<0.1	12	11.5	<0.01	<0.3	45	<0.05	<0.6	<0.05	<0.003	0.004	3.24	260	0.626	0.0
6	<0.005	<0.01	0.010	0.403	0.066	<0.0005	106.0	<0.01	66	0.08	0.10	0.011	0.03	<0.1	13	12.4	<0.01	<0.3	49	<0.05	<0.6	<0.05	<0.003	0.005	3.31	330	0.732	0.0
7	<0.005	<0.01	0.006	0.441	0.061	<0.0005	122.0	<0.01	81	<0.05	0.09	<0.008	<0.01	<0.1	13	13.6	<0.01	<0.3	47	<0.05	<0.6	<0.05	<0.003	0.005	3.41	300	0.887	0.0
8	<0.005	0.12	0.004	0.353	0.074	<0.0005	127.0	<0.01	70	<0.05	<0.01	0.010	0.07	<0.1	13	14.3	<0.01	<0.3	52	<0.05	<0.6	<0.05	<0.003	0.005	4.59	320	0.978	0.0
9	<0.005	0.20	0.070	0.417	0.079	<0.0005	147.0	<0.01	78	0.24	<0.01	0.018	0.06	<0.1	16	15.5	<0.01	0.6	59	<0.05	<0.6	<0.05	<0.003	0.007	4.78	390	1.12	0.1
10	<0.005	0.18	0.013	0.421	0.053	<0.0005	159.0	<0.01	57	<0.05	<0.01	<0.008	0.04	<0.1	12	17.0	0.02	<0.3	52	<0.05	<0.6	<0.05	<0.003	0.008	4.85	380	1.22	<0.0
11	<0.005	0.19	0.004	0.409	0.056	<0.0005	151.0	<0.01	68	<0.05	<0.01	0.014	0.04		11	15.9	0.02	<0.3	49	<0.05	<0.6	<0.05	<0.003	0.010	4.87	430	1.33	<0.0
12	<0.005	0.24	0.046	0.349	0.060	<0.0005	178.0	<0.01	64	<0.05	<0.01	0.013	0.04		16	17.4	0.08	0.3	51	<0.05	<0.6	<0.05	<0.003	0.011	5.59	550	1.37	0.0
13	<0.005	0.34	0.010	0.382	0.059	<0.0005	190.0	<0.01	70	0.10	<0.01	0.041	0.13		15	17.8	0.03	<0.3	50	<0.05	<0.6	<0.05	<0.003	0.014	5.72	450	1.43	<0.0
14	<0.005	0.13	0.021	0.682	0.047	<0.0005	205.0	<0.01	64	<0.05	0.02	0.010	0.09		15	18.9	0.14	<0.3	47	0.06	<0.6	<0.05		0.010	5.93	580	1.38	0.0
15	<0.005	0.11		0.899	0.046	<0.0005	235.0	<0.01	70	<0.05	0.01	<0.008	0.13	<0.2	16	21.9	0.21	<0.3	54	0.06	<0.6	<0.05	<0.003		6.88	710	1.75	<0.0
16	<0.005	0.11		0.907	0.041	<0.0005	240.0	<0.01	68	<0.05	<0.01	<0.008	0.03		16	22.1	0.23	<0.3	52	<0.05	<0.6	<0.05	<0.003		6.65	700	1.81	<0.0
17	<0.005	0.18		1.02	0.041	<0.0005	280.0	<0.01	63	0.08	0.02	0.012	0.07		16	25.7	0.30	<0.3	54	0.08	<0.6	<0.05			8.35	730	1.98	0.0
18	<0.005	0.34		1.00	0.040	<0.0005	291.0	<0.01	61	0.27	0.02	0.026	0.12	<0.2	19	25.9	0.43	0.5	66	0.11	<0.6	<0.05	<0.003		8.70	570	1.88	0.1
19	<0.005	0.64		1.07	0.049	<0.0005	307.0	<0.01	61	0.27	0.01	0.036	0.12		17	27.7	0.57	0.5	50	0.13	<0.6	<0.05			9.77	710	1.99	0.1
20	<0.005	0.53		1.16	0.047	<0.0005	298.0	<0.01	66	<0.05	0.06	0.020	0.07	0.1	13	27.7	0.68	<0.3	50	0.13	<0.6	<0.05	<0.003		10.5	860	2.35	0.0

NANTICOKE BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
<0.01	<0.008	0.01	0.2	13	9.60	<0.01	<0.3	54	<0.05	<0.6	<0.05	0.005	0.022	0.30	810	0.284	0.03	<0.005	0.007	2.8	<0.005	<0.05	<0.05	0.63	94		7.80
0.05		0.04	1.2	13	9.75	<0.01	<0.3	52	<0.05	<0.6	<0.05	<0.003	<0.003	1.03	81	0.351	0.08	<0.005	0.006	2.0	<0.005	0.16	<0.05	0.67	100	700	7.70
<0.01	<0.008	0.02	0.4	13	9.75	<0.01	<0.3	49	<0.05	<0.6	<0.05	<0.003	<0.003	1.46	96	0.407	0.11	<0.005	0.007		0.008	<0.05	<0.05	0.70	78	490	7.70
<0.01	<0.008	0.01	0.3	13	10.6	<0.01	<0.3	52	<0.05	<0.6	<0.05	<0.003	<0.003	1.92	130	0.471	0.08	<0.005	0.006		<0.005	<0.05	<0.05	0.76	78	480	7.70
<0.01	<0.008	0.05	<0.1	12	11.1	<0.01	<0.3	48	<0.05	<0.6	<0.05	<0.003	<0.003	2.88	210	0.600	0.01	<0.005	0.006		<0.005	<0.05	<0.05	0.80	76	550	7.60
<0.01	<0.008	0.02	<0.1	12	11.5	<0.01	<0.3	45	<0.05	<0.6	<0.05	<0.003	0.004	3.24	260	0.626	0.03	<0.005	0.006		0.006	<0.05	<0.05	0.87	72	560	7.65
0.10	0.011	0.03	<0.1	13	12.4	<0.01	<0.3	49	<0.05	<0.6	<0.05	<0.003	0.005	3.31	330	0.732	0.04	0.005	0.007		0.009	0.05	<0.05	0.90	64	650	7.70
0.09	<0.008	<0.01	<0.1	13	13.6	<0.01	<0.3	47	<0.05	<0.6	<0.05	<0.003	0.005	3.41	300	0.887	0.02	<0.005	0.005		0.005	<0.05	<0.05	0.94	106	700	7.70
<0.01	0.010	0.07	<0.1	13	14.3	<0.01	<0.3	52	<0.05	<0.6	<0.05	<0.003	0.005	4.59	320	0.978	0.01	<0.005	0.006		0.009	0.10	<0.05	0.96	68	700	7.60
<0.01	0.018	0.06	<0.1	16	15.5	<0.01	0.6	59	<0.05	<0.6	<0.05	<0.003	0.007	4.78	390	1.12	0.15	0.008	0.006		0.035	<0.05	<0.05	1.00	40	740	7.50
<0.01	<0.008	0.04	<0.1	12	17.0	0.02	<0.3	52	<0.05	<0.6	<0.05	<0.003	0.008	4.85	380	1.22	<0.01	<0.005	0.005		<0.005	<0.05	<0.05		40	800	7.40
<0.01	0.014	0.04		11	15.9	0.02	<0.3	49	<0.05	<0.6	<0.05	<0.003	0.010	4.87	430	1.33	<0.01	0.006	0.007	4.0	<0.005	<0.05	<0.05	1.10	32	840	7.30
<0.01	0.013	0.04		16	17.4	0.08	0.3	51	<0.05	<0.6	<0.05	<0.003	0.011	5.59	550	1.37	0.04	<0.005	0.009		0.010	<0.05	<0.05	1.20	32	950	7.30
<0.01	0.041	0.13		15	17.8	0.03	<0.3	50	<0.05	<0.6	<0.05	<0.003	0.014	5.72	450	1.43	<0.01	0.010	0.010		<0.005	0.09	<0.05	1.40	25	930	7.20
0.02	0.010	0.09		15	18.9	0.14	<0.3	47	0.06	<0.6	<0.05		0.010	5.93	580	1.38	0.03	<0.005	0.010		0.021	0.21	<0.05	1.40	18	1 070	7.00
0.01	<0.008	0.13	<0.2	16	21.9	0.21	<0.3	54	0.06	<0.6	<0.05	<0.003		6.88	710	1.75	<0.01	<0.005	0.022		0.014		<0.05	1.40	14	1 090	6.60
<0.01	<0.008	0.03		16	22.1	0.23	<0.3	52	<0.05	<0.6	<0.05	<0.003		6.65	700	1.81	<0.01	<0.005	0.022	<0.2	0.012	<0.05	<0.05	1.40	12	1 180	6.60
0.02	0.012	0.07		16	25.7	0.30	<0.3	54	0.08	<0.6	<0.05			8.35	730	1.98	0.09	<0.005	0.022		0.035	0.08	<0.05	1.58	4	1 220	6.20
0.02	0.026	0.12	<0.2	19	25.9	0.43	0.5	66	0.11	<0.6	<0.05	<0.003		8.70	570	1.88	0.18	0.010	0.004		0.050	0.06	<0.05	1.67	1	1 330	5.60
0.01	0.036	0.12		17	27.7	0.57	0.5	50	0.13	<0.6	<0.05			9.77	710	1.99	0.17	0.013	0.024		0.055	0.07	<0.05	1.70	6	1 410	5.00
0.06	0.020	0.07	0.1	13	27.7	0.68	<0.3	50	0.13	<0.6	<0.05	<0.003		10.5	860	2.35	0.05	<0.005	0.008	<0.2	0.041	0.10	<0.05	1.80	6	1 480	5.20

DALHOUSIE FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr
0	<0.005	<0.01	< 0.002	0.046	0.118	<0.0005	81.	<0.01	14	<0.05	<0.01	<0.008	0.05	1.0	3	2.29	<0.01	<0.3	35	<0.05	<0.6	<0.05	<0.003	<0.003	2.20	130	0.215
1	<0.005	<0.01	6.06	0.214	0.048	<0.0005	171.	<0.01	14	<0.05	<0.01	<0.008	0.02	0.2	19	3.70	0.88	2.0	40	<0.05	2.5	<0.05	0.037	<0.003	4.10	400	0.430
2	<0.005	0.17	11.1	0.390	0.045	<0.0005	277.	<0.01	13	0.07	<0.01	0.036	0.03	<0.1	34	5.16	1.77	3.2	43	0.10	6.5	<0.05	0.052	<0.003	6.53	700	0.684
3	<0.005	0.26	10.1	0.498	0.033	<0.0005	400.	<0.01	13	<0.05	<0.01	0.046	0.04	0.1	48	6.76	2.74	4.0	48	0.12	9.6	<0.05	0.055	0.007	8.50	950	0.877
4	<0.005	0.35	11.5	0.676	0.042	<0.0005	493.	<0.01	11	<0.05	<0.01	0.053	0.06	<0.1	58	8.38	3.34	5.1	53	0.17	11.1	<0.05	0.061	0.007	12.9	1 280	1.26
5	<0.005	0.17	17.1	0.821	0.040	<0.0005	613.	0.01	13	<0.05	<0.01	0.059	0.07	<0.1	77	9.71	3.76	6.2	75	0.16	13.7	<0.05	0.061	0.011	16.1	1 660	1.33
6	<0.005	0.13	8.99	0.957	0.015	<0.0005	662.	<0.01	10	0.07	0.10	0.020	0.05	<0.1	94	11.6	3.22	7.4	87	0.22	7.9	<0.05	0.065	0.012	19.4	1 750	1.50
7	<0.005	<0.01	21.5	1.11	0.035	<0.0005	742.	0.02	15	<0.05	0.18	0.155	0.75	<0.1	106	13.0	4.66	7.4	67	0.25	15.9	<0.05	0.080	0.020	19.9	1 690	1.77
8	<0.005	1.51	22.1	0.908	0.053	<0.0005	799.	0.01	14	0.08	<0.01	0.185	0.06	<0.1	125	14.9	5.68	7.3	88	0.23	15.9	<0.05	0.071	0.014	24.1	930	1.96
9	<0.005	1.41	19.7	1.02	0.084	<0.0005	771.	<0.01	17	0.13	<0.01	0.191	0.08	<0.1	145	16.3	6.07	7.1	89	0.27	14.8	<0.05	0.072	0.026	25.3	1 530	2.06
10	<0.005	1.42	13.1	0.978	0.056	<0.0005	794.	0.01	13	<0.05	<0.01	0.147	0.11	<0.1	160	18.6	6.45	5.9	98	0.25	11.4	<0.05	0.067	0.025	24.0	1 870	2.16
11	<0.005	1.32	4.80	1.04	0.068	<0.0005	755.	0.01	14	<0.05	<0.01	0.160	0.01		175	18.7	7.13	5.4	97	0.24	8.8	<0.05	0.065	0.025	25.4	2 070	2.49
12	<0.005	1.08	7.93	0.818	0.070	<0.0005	721.	0.01	16	0.06	<0.01	0.159	0.11		181	19.5	6.49	5.7	98	0.27	5.7	<0.05	0.068	0.026	25.3	1 990	2.20
13	<0.005	1.22	6.06	0.820	0.066	<0.0005	701.	<0.01	17	<0.05	0.04	0.332	0.18		190	19.8	6.23	5.4	100	0.26	4.4	<0.05	0.061	0.033	23.4	2 260	2.07
14	<0.005	0.63	3.62	1.44	0.056	<0.0005	714.	0.02	19	<0.05	0.02	0.110	0.20		211	19.5	4.53	5.7	102	0.24	2.7	<0.05		0.026	21.2	2 300	2.05
15	<0.005	0.56		1.61	0.063	<0.0005	682.	0.02	22	<0.05	<0.01	0.116	0.35	<0.2	239	20.8	4.64	6.1	116	0.25	2.3	<0.05	0.020		20.7	2 190	2.30
16	<0.005	0.54		1.61	0.034	<0.0005	677.	<0.01	19	<0.05	<0.01	0.097	0.05		258	20.2	3.95	5.9	122	0.20	1.7	<0.05	0.020		17.5	2 150	2.29
17	<0.005	0.78		1.72	0.044	<0.0005	713.	0.02	15	<0.05	0.01	0.108	0.08		285	22.0	4.15	6.2	135	0.22	1.6	<0.05			19.0	2 280	2.43
18	<0.005	0.64		1.68	0.044	<0.0005	714.	<0.01	15	<0.05	<0.01	0.054	0.08	<0.2	296	20.8	3.43	6.7	157	0.17	1.7	<0.05	0.009		15.8	2 530	2.36
19	<0.005	0.62		1.65	0.052	<0.0005	713.	0.01	11	0.14	<0.01	0.069	0.10		297	20.9	3.31	6.4	135	0.20	1.4	<0.05			14.6	2 380	2.26
20	<0.005	1.12		1.65	0.047	<0.0005	663.	0.03	21	0.19	0.05	0.055	0.13	<0.1	295	19.6	3.03	6.2	137	0.20	1.4	<0.05	0.016		12.1	2 580	2.33

DALHOUSIE FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
<0.01	<0.008	0.05	1.0	3	2.29	<0.01	<0.3	35	<0.05	<0.6	<0.05	<0.003	<0.003	2.20	130	0.215	0.06	<0.005	0.008	2.2	<0.005	<0.05	<0.05	0.55	64		7.70
<0.01	<0.008	0.02	0.2	19	3.70	0.88	2.0	40	<0.05	2.5	<0.05	0.037	<0.003	4.10	400	0.430	0.13	<0.005	0.100	3.2	0.044	<0.05	<0.05	1.00	10	700	6.60
<0.01	0.036	0.03	<0.1	34	5.16	1.77	3.2	43	0.10	6.5	<0.05	0.052	<0.003	6.53	700	0.684	0.19	<0.005	0.202		0.058	0.06	<0.05	1.40	6	1 330	5.20
<0.01	0.046	0.04	0.1	48	6.76	2.74	4.0	48	0.12	9.6	<0.05	0.055	0.007	8.50	950	0.877	0.23	<0.005	0.260		0.060	0.07	<0.05	1.90	8	1 890	5.10
<0.01	0.053	0.06	<0.1	58	8.38	3.34	5.1	53	0.17	11.1	<0.05	0.061	0.007	12.9	1 280	1.26	<0.01	<0.005	0.308		0.044	0.08	<0.05	2.30	6	2 410	5.20
<0.01	0.059	0.07	<0.1	77	9.71	3.76	6.2	75	0.16	13.7	<0.05	0.061	0.011	16.1	1 660	1.33	<0.01	<0.005	0.210		0.047	0.09	<0.05	2.70	10	2 800	5.30
0.10	0.020	0.05	<0.1	94	11.6	3.22	7.4	87	0.22	7.9	<0.05	0.065	0.012	19.4	1 750	1.50	<0.01	0.005	0.240		0.066	<0.05	<0.05	3.00	10	3 190	5.30
0.18	0.155	0.75	<0.1	106	13.0	4.66	7.4	67	0.25	15.9	<0.05	0.080	0.020	19.9	1 690	1.77	<0.01	<0.005	0.380		0.054	0.21	<0.05	3.19	10	3 460	5.14
<0.01	0.185	0.06	<0.1	125	14.9	5.68	7.3	88	0.23	15.9	<0.05	0.071	0.014	24.1	930	1.96	<0.01	<0.005	0.412		0.152	0.09	<0.05	3.39	10	3 670	5.20
<0.01	0.191	0.08	<0.1	145	16.3	6.07	7.1	89	0.27	14.8	<0.05	0.072	0.026	25.3	1 530	2.06	0.02	<0.005	0.440		0.157	0.12	<0.05	3.60	18	3 590	4.80
<0.01	0.147	0.11	<0.1	160	18.6	6.45	5.9	98	0.25	11.4	<0.05	0.067	0.025	24.0	1 870	2.16	<0.01	<0.005	0.432		0.123	0.12	<0.05		< 1	3 700	
<0.01	0.160	0.01		175	18.7	7.13	5.4	97	0.24	8.8	<0.05	0.065	0.025	25.4	2 070	2.49	<0.01	<0.005	0.450	1.2	0.099	0.11	<0.05	3.60	4	3 630	5.10
<0.01	0.159	0.11		181	19.5	6.49	5.7	98	0.27	5.7	<0.05	0.068	0.026	25.3	1 990	2.20	<0.01	<0.005	0.460		0.120	0.13	<0.05	3.80	10	3 660	5.50
0.04	0.332	0.18		190	19.8	6.23	5.4	100	0.26	4.4	<0.05	0.061	0.033	23.4	2 260	2.07	<0.01	0.008	0.460		0.126		<0.05	4.20	6	3 540	5.20
0.02	0.110	0.20		211	19.5	4.53	5.7	102	0.24	2.7	<0.05		0.026	21.2	2 300	2.05	<0.01	<0.005	0.460		0.120	0.15	<0.05	4.04	< 1	3 760	5.87
<0.01	0.116	0.35	<0.2	239	20.8	4.64	6.1	116	0.25	2.3	<0.05	0.020		20.7	2 190	2.30	<0.01	<0.005	0.496		0.122		<0.05	3.85	10	3 620	5.90
<0.01	0.097	0.05		258	20.2	3.95	5.9	122	0.20	1.7	<0.05	0.020		17.5	2 150	2.29	<0.01	<0.005	0.420	<0.2	0.096	0.11	<0.05	3.72	10	3 750	6.15
0.01	0.108	0.08		285	22.0	4.15	6.2	135	0.22	1.6	<0.05			19.0	2 280	2.43	<0.01	<0.005	0.370		0.105	0.21	<0.05	4.10	< 1	3 750	6.30
<0.01	0.054	0.08	<0.2	296	20.8	3.43	6.7	157	0.17	1.7	<0.05	0.009		15.8	2 530	2.36	<0.01	<0.005	0.340		0.089	0.10	<0.05	4.35	10	3 830	6.90
<0.01	0.069	0.10		297	20.9	3.31	6.4	135	0.20	1.4	<0.05			14.6	2 380	2.26	0.04	<0.005	0.420		0.120	0.10	<0.05	4.20	14	3 770	6.45
0.05	0.055	0.13	<0.1	295	19.6	3.03	6.2	137	0.20	1.4	<0.05	0.016		12.1	2 580	2.33	0.15	<0.005	0.740	<0.2	0.108	0.17	<0.05	4.00	22	3 770	7.20

DALHOUSIE BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (µg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr
0	<0.005	<0.01	<0.002	0.046	0.118	<0.0005	81.0	<0.01	14	<0.05	<0.01	<0.008	0.05	1.0	3	2.29	<0.01	<0.3	35	<0.05	<0.6	<0.05	<0.003	<0.003	2.20	130	0.215
1	<0.005	<0.01	0.034	0.070	0.164	<0.0005	99.8	<0.01	14	<0.05	<0.01	<0.008	0.02	0.3	4	2.62	0.09	<0.3	37	<0.05	<0.6	<0.05	<0.003	<0.003	2.60	180	0.228
2	<0.005	<0.01	0.046	0.083	0.028	<0.0005	118.	<0.01	13	0.06	<0.01	<0.008	0.02	<0.1	4	2.95	0.13	<0.3	40	<0.05	<0.6	<0.05	<0.003	<0.003	2.69	250	0.268
3	<0.005	<0.01	0.050	0.059	0.023	<0.0005	147.	<0.01	13	<0.05	<0.01	<0.008	0.03	<0.1	5	3.48	0.19	<0.3	45	<0.05	<0.6	<0.05	<0.003	<0.003	2.92	280	0.290
4	<0.005	0.05	0.025	0.096	0.025	<0.0005	152.	<0.01	16	<0.05	<0.01	<0.008	0.02	<0.1	5	3.77	0.23	<0.3	46	<0.05	<0.6	<0.05	<0.003	<0.003	3.45	410	0.354
5	<0.005	<0.01	0.040	0.089	0.021	<0.0005	196.	<0.01	14	<0.05	<0.01	<0.008	0.02	<0.1	5	4.38	0.27	<0.3	49	<0.05	<0.6	<0.05	<0.003	0.006	4.00	570	0.355
6	<0.005	<0.01	0.036	0.105	0.028	<0.0005	210.	<0.01	12	0.06	0.04	<0.008	0.02	<0.1	7	4.87	0.26	<0.3	54	0.06	<0.6	<0.05	<0.003	<0.003	4.24	620	0.369
7	<0.005	<0.01	0.013	0.127	0.017	<0.0005	241.	<0.01	17	<0.05	0.03	<0.008	0.02	<0.1	7	5.52	0.38	<0.3	56	0.05	0.6	<0.05	<0.003	0.007	4.16	810	0.468
8	<0.005	0.42	0.015	0.083	0.029	<0.0005	240.	<0.01	14	<0.05	<0.01	0.017	0.02	<0.1	7	5.42	0.36	<0.3	58	<0.05	<0.6	<0.05	<0.003	0.008	4.26	610	0.458
9	<0.005	0.55	0.024	0.092	0.023	<0.0005	265.	<0.01	16	0.12	<0.01	0.010	0.06	<0.1	8	5.90	0.40	0.3	63	0.11	<0.6	<0.05	0.003	0.009	4.36	840	0.501
10	<0.005	0.72	0.013	0.099	0.012	<0.0005	306.	<0.01	17	<0.05	<0.01	<0.008	0.04	<0.1	8	6.84	0.46	<0.3	65	<0.05	<0.6	<0.05	<0.003	0.011	4.52	870	0.546
11	<0.005	0.87	0.013	0.147	0.019	<0.0005	328.	0.01	13	0.14	<0.01	<0.008	0.13		11	7.18	0.51	0.4	69	<0.05	0.6	<0.05	<0.003	0.012	4.80	840	0.634
12	<0.005	0.49	0.018	0.059	0.011	<0.0005	355.	<0.01	25	<0.05	<0.01	0.014	0.04		10	7.25	0.50	<0.3	68	<0.05	0.6	<0.05	<0.003	0.018	4.76	870	0.662
13	<0.005	2.07	0.016	0.134	0.013	<0.0005	374.	<0.01	20	<0.05	<0.01	0.047	0.07		15	8.71	0.58	<0.3	74	<0.05	<0.6	<0.05	<0.003	0.014	5.36	950	0.772
14	<0.005	0.46	0.014	0.125	<0.005	<0.0005	418.	<0.01	17	<0.05	<0.01	<0.008	0.08		11	8.57	0.53	<0.3	75	0.06	0.6	<0.05		0.015	5.20	1 260	0.690
15	<0.005	0.62		0.216	<0.005	<0.0005	442.	<0.01	19	<0.05	<0.01	0.998	0.08	<0.2	14	9.28	0.70	<0.3	75	0.08	<0.6	<0.05	<0.003		5.62	1 300	0.759
16	<0.005	0.69		0.280	<0.005	<0.0005	440.	<0.01	17	<0.05	<0.01	<0.008	0.04		15	9.93	0.76	<0.3	83	0.06	<0.6	<0.05	<0.003		5.36	1 180	0.849
17	<0.005	0.51		0.187	<0.005	<0.0005	502.	<0.01	16	<0.05	<0.01	<0.008	0.06		13	10.2	0.95	<0.3	86	0.06	<0.6	<0.05			6.01	1 450	0.843
18	<0.005	0.43		0.284	<0.005	<0.0005	534.	<0.01	17	0.05	<0.01	0.017	0.08	<0.2	17	11.6	1.10	<0.3	91	0.08	<0.6	<0.05	0.003		6.63	1 420	0.926
19	<0.005	1.41		0.274	<0.005	<0.0005	572.	<0.01	18	0.19	<0.01	0.022	0.10		19	12.5	1.33	0.4	90	0.10	0.7	<0.05			6.73		0.914
20	<0.005	0.89		0.201	<0.005	<0.0005	562.	0.02	18	0.11	0.03	0.018	0.11	<0.1	15	11.7	1.47	0.3	94	0.10	0.7	<0.05	<0.003		6.55	1 560	1.02

DALHOUSIE BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
5	<0.01	<0.008	0.05	1.0	3	2.29	<0.01	<0.3	35	<0.05	<0.6	<0.05	<0.003	<0.003	2.20	130	0.215	0.06	<0.005	0.008	2.2	<0.005	<0.05	<0.05	0.55	64	130	7.70
5	<0.01	<0.008	0.02	0.3	4	2.62	0.09	<0.3	37	<0.05	<0.6	<0.05	<0.003	<0.003	2.60	180	0.228	0.11	<0.005	0.009	0.8	<0.005	0.14	<0.05	0.65	120	300	7.80
6	<0.01	<0.008	0.02	<0.1	4	2.95	0.13	<0.3	40	<0.05	<0.6	<0.05	<0.003	<0.003	2.69	250	0.268	0.10	<0.005	0.008		0.005	<0.05	<0.05	0.70	64	550	7.75
5	<0.01	<0.008	0.03	<0.1	5	3.48	0.19	<0.3	45	<0.05	<0.6	<0.05	<0.003	<0.003	2.92	280	0.290	0.12	<0.005	0.007		<0.005	<0.05	<0.05	0.92	62	630	7.70
5	<0.01	<0.008	0.02	<0.1	5	3.77	0.23	<0.3	46	<0.05	<0.6	<0.05	<0.003	<0.003	3.45	410	0.354	<0.01	<0.005	0.009		<0.005	<0.05	<0.05	0.95	60	730	7.60
5	<0.01	<0.008	0.02	<0.1	5	4.38	0.27	<0.3	49	<0.05	<0.6	<0.05	<0.003	0.006	4.00	520	0.355	<0.01	<0.005	0.007		<0.005	<0.05	<0.05	1.08	60	980	7.80
6	0.04	<0.008	0.02	<0.1	7	4.87	0.26	<0.3	54	0.06	<0.6	<0.05	<0.003	<0.003	4.24	620	0.369	<0.01	<0.005	0.007		<0.005	<0.05	<0.05	1.20	58	980	7.65
5	0.03	<0.008	0.02	<0.1	7	5.52	0.38	<0.3	56	0.05	0.6	<0.05	<0.003	0.007	4.16	810	0.468	<0.01	<0.005	0.011		<0.005	0.19	<0.05	1.25	54	1 030	7.60
5	<0.01	0.017	0.02	<0.1	7	5.42	0.36	<0.3	58	<0.05	<0.6	<0.05	<0.003	0.008	4.26	610	0.458	0.05	<0.005	0.007		0.008	<0.05	<0.05	1.31	56	1 110	7.70
2	<0.01	0.010	0.06	<0.1	8	5.90	0.40	0.3	63	0.11	<0.6	<0.05	0.003	0.009	4.36	840	0.501	0.07	<0.005	0.011		0.016	<0.05	<0.05	1.45	52	1 230	7.80
5	<0.01	<0.008	0.04	<0.1	8	6.84	0.46	<0.3	65	<0.05	<0.6	<0.05	<0.003	0.011	4.52	870	0.546	<0.01	0.006	0.009		<0.005	<0.05	<0.05		52	1 340	
4	<0.01	<0.008	0.13		11	7.18	0.51	0.4	69	<0.05	0.6	<0.05	<0.003	0.012	4.80	840	0.634	<0.01	0.020	0.009	0.4	0.018	<0.05	<0.05	1.60	46	1 480	7.80
5	<0.01	0.014	0.04		10	7.25	0.50	<0.3	68	<0.05	0.6	<0.05	<0.003	0.018	4.76	870	0.662	<0.01	<0.005	0.009		<0.005	0.14	<0.05	1.95	44	1 600	7.70
5	<0.01	0.047	0.07		15	8.71	0.58	<0.3	74	<0.05	<0.6	<0.05	<0.003	0.014	5.36	950	0.772	<0.01	0.005	0.010		<0.005	0.08	<0.05	2.20	42	1 630	7.55
5	<0.01	<0.008	0.08		11	8.57	0.53	<0.3	75	0.06	0.6	<0.05		0.015	5.20	1 260	0.690	<0.01	<0.005	0.009		<0.005	<0.05	<0.05	2.20	24	2 120	7.60
5	<0.01	0.998	0.08	<0.2	14	9.28	0.70	<0.3	75	0.08	<0.6	<0.05	<0.003		5.62	1 300	0.759	0.02	<0.005	0.031		0.008	0.07	<0.05	2.19	43	1 890	7.40
5	<0.01	<0.008	0.04		15	9.93	0.76	<0.3	83	0.06	<0.6	<0.05	<0.003		5.36	1 180	0.849	<0.01	<0.005	0.039	0.4	<0.005	0.07	<0.05	2.20	38	2 050	7.50
5	<0.01	<0.008	0.06		13	10.2	0.95	<0.3	86	0.06	<0.6	<0.05			6.01	1 450	0.843	<0.01	<0.005	0.032		<0.005	<0.05	<0.05	2.45	32	2 200	7.30
5	<0.01	0.017	0.08	<0.2	17	11.6	1.10	<0.3	91	0.08	<0.6	<0.05	0.003		6.63	1 420	0.926	0.02	<0.005	0.012		0.009	0.13	<0.05	2.60	20	2 250	7.30
9	<0.01	0.022	0.10		19	12.5	1.33	0.4	90	0.10	0.7	<0.05			6.73		0.914	0.10	0.007	0.038		0.027	<0.05	<0.05	2.55	30	2 360	7.30
1	0.03	0.018	0.11	<0.1	15	11.7	1.47	0.3	94	0.10	0.7	<0.05	<0.003		6.55	1 560	1.02	0.13	<0.005	0.010	5.6	0.029	<0.05	<0.05	2.70	22	2 450	7.09

LINGAN FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr
0	<0.005	2.75	0.010	0.795	0.199	<0.0005	101	<0.01	23	<0.05	<0.01	0.067	0.06	0.2	30	7.90	1.21	<0.3	35	0.08	<0.6	<0.05	<0.003	<0.003	3.60	280	0.44
1	<0.005	11.2	0.288	1.24	0.108	0.0018	140	<0.01	18	<0.05	<0.01	0.262	0.09	0.3	46	10.4	1.45	<0.3	48	0.14	<0.6	<0.05	<0.003	<0.003	6.06	460	0.71
2	<0.005	21.9	0.438	1.63	0.116	0.0042	173	0.02	17	0.08	<0.01	0.461	0.18	0.1	62	12.5	1.61	<0.3	59	0.19	<0.6	<0.05	<0.003	<0.003	8.18	640	1.01
3	<0.005	33.9	0.336	2.01	0.118	0.0064	223	0.03	18	<0.05	<0.01	0.632	0.18	0.1	76	15.7	1.85	<0.3	76	0.28	<0.6	<0.05	<0.003	0.008	10.8	850	1.29
4	<0.005	43.6	0.252	2.57	0.123	0.0090	255	0.04	21	<0.05	<0.01	0.868	0.19	<0.1	88	20.1	2.18	<0.3	90	0.33	<0.6	<0.05	<0.003	0.005	15.6	1 040	1.80
5	<0.005	49.1	0.105	3.33	0.111	0.0104	316	0.06	19	0.07	<0.01	0.961	0.23	<0.1	112	21.9	2.44	<0.3	100	0.42	<0.6	<0.05	<0.003	0.007	19.2	1 320	1.94
6	<0.005	61.6	0.180	3.52	0.097	0.0110	321	0.06	18	0.10	0.26	1.05	0.40	<0.1	125	22.7	2.43	<0.3	274	0.48	<0.6	0.05	<0.003	0.011	22.0	1 460	2.15
7	<0.005	78.2	0.110	4.15	0.087	0.0148	395	0.08	20	<0.05	0.30	1.40	0.62	0.1	149	28.0	2.88	<0.3	311	0.60	<0.6	<0.05	<0.003	0.014	26.6	1 560	2.87
8	<0.005	104.	0.115	3.73	0.078	0.0215	427	0.10	19	0.18	0.13	1.65	1.58	<0.1	171	32.2	3.57	<0.3	400	0.71	<0.6	<0.05	<0.003	0.014	33.2		3.35
9	<0.005	110.	0.014	4.16	0.083	0.0236	452	0.11	22	0.24	0.09	1.76	0.88	<0.1	197	35.6	3.88	0.3	184	0.82	<0.6	<0.05	<0.003	0.013	33.9	1 470	3.98
10	<0.005	154.	0.013	4.31	0.055	0.0270	535	0.12	55	<0.05	0.09	1.97	1.10	<0.1	220	48.7	4.72	<0.3	201	0.87	<0.6	<0.05	<0.003	0.014	37.7	2 310	4.43
11	<0.005	164.	0.016	4.82	0.087	0.0312	555	0.13	25	0.09	0.07	2.26	0.97		238	52.3	5.67	<0.3	217	1.06	<0.6	<0.05	<0.003	0.018	39.1	3 110	5.33
12	<0.005	161.	0.038	4.03	0.105	0.0316	565	0.14	31	0.15	0.05	2.14	0.84		245	59.4	5.78	0.3	222	1.07	<0.6	<0.05	<0.003	0.018	42.7	2 800	5.08
13	<0.005	179.	0.054	4.26	0.085	0.0348	575	0.17	23	0.23	0.04	2.19	1.00		269	68.4	6.30	<0.3	245	1.24	<0.6	<0.05	<0.003	0.018	43.8	2 320	5.83
14	<0.005	167.	0.015	9.44	0.031	0.0344	595	0.18	22	0.27	0.08	1.98	1.12		295	65.4	6.40	<0.3	266	1.33	<0.6	<0.05		0.018	48.0	2 780	6.21
15	<0.005	165.		10.2	0.091	0.0340	581	0.21	24	0.36	0.06	1.78	1.00	<0.2	295	71.1	6.47	<0.3	284	1.45	<0.6	<0.05	0.003		49.4	2 650	5.84
16	<0.005	172.		11.1	0.095	0.0344	574	0.20	26	0.23	<0.01	1.58	0.87		325	77.5	6.74	<0.3	315	1.49	<0.6	<0.05	0.003		46.4	3 000	6.31
17	<0.005	180.		11.8	0.065	0.0403	611	0.24	20	0.36	0.04	1.39	0.89		328	88.4	7.80	<0.3	342	1.76	<0.6	<0.05			58.8	2 800	6.77
18	<0.005	176.		13.2	0.033	0.0393	587	0.24	21	0.38	<0.01	1.14	0.83	<0.2	385	94.7	8.37	0.3	346	1.80	<0.6	<0.05	0.005		60.1	2 850	6.71
19	<0.005	183.		13.8	0.034	0.0404	591	0.24	17	0.33	<0.01	1.16	0.83		437	95.4	8.14	<0.3	363	1.78	<0.6	<0.05			61.9	2 570	6.87
20	<0.005	193.		16.8	0.052	0.0462	581	0.33	48	0.60	0.10	0.855	0.79	0.2	352	116.	10.6	0.5	417	2.40	<0.6	<0.05	0.003		68.4		8.02

LINGAN FLY - BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

	Cr	Cu	Fe	Hg (µg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (µg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
.05	<0.01	0.067	0.06	0.2	30	7.90	1.21	<0.3	35	0.08	<0.6	<0.05	<0.003	<0.003	3.60	280	0.445	0.06	<0.005	0.028	1.8	<0.005	0.18	<0.05	0.80	1	600	4.35
.05	<0.01	0.262	0.09	0.3	46	10.4	1.45	<0.3	48	0.14	<0.6	<0.05	<0.003	<0.003	6.06	460	0.713	0.08	<0.005	0.120	2.0	<0.005	0.43	<0.05	1.12	<1	960	4.40
.08	<0.01	0.461	0.18	0.1	62	12.5	1.61	<0.3	59	0.19	<0.6	<0.05	<0.003	<0.003	8.18	640	1.01	0.11	<0.005	0.350		<0.005	0.66	<0.05	1.40	<1	1 270	4.20
.05	<0.01	0.632	0.18	0.1	76	15.7	1.85	<0.3	76	0.28	<0.6	<0.05	<0.003	0.008	10.8	850	1.29	0.07	0.005	0.476		<0.005	0.96	<0.05	1.80	<1	1 640	4.00
.05	<0.01	0.868	0.19	<0.1	88	20.1	2.18	<0.3	90	0.33	<0.6	<0.05	<0.003	0.005	15.6	1 040	1.80	<0.01	<0.005	0.562		<0.005	1.16	<0.05	2.00	<1	1 900	4.00
.07	<0.01	0.961	0.23	<0.1	112	21.9	2.44	<0.3	100	0.42	<0.6	<0.05	<0.003	0.007	19.2	1 320	1.94	<0.01	0.007	0.590		<0.005	1.61	<0.05	2.30	<1	2 260	4.00
.10	0.26	1.05	0.40	<0.1	125	22.7	2.43	<0.3	274	0.48	<0.6	0.05	<0.003	0.011	22.0	1 460	2.15	<0.01	0.009	0.608		<0.005	1.83	0.06	2.65	<1	2 650	3.90
.05	0.30	1.40	0.62	0.1	149	28.0	2.88	<0.3	311	0.60	<0.6	<0.05	<0.003	0.014	26.6	1 560	2.87	<0.01	0.019	0.800		<0.005	2.38	0.11	2.90	<1	3 090	3.85
.18	0.13	1.65	1.58	<0.1	171	32.2	3.57	<0.3	400	0.71	<0.6	<0.05	<0.003	0.014	33.2		3.35	0.03	0.008	0.930		<0.005	2.90	0.08	3.30	<1	3 870	3.90
.24	0.09	1.76	0.88	<0.1	197	35.6	3.88	0.3	184	0.82	<0.6	<0.05	<0.003	0.013	33.9	1 470	3.98	0.09	0.012	1.03		0.007	3.32	0.08	3.90	<1	3 890	3.95
.05	0.09	1.97	1.10	<0.1	220	48.7	4.72	<0.3	201	0.87	<0.6	<0.05	<0.003	0.014	37.7	2 310	4.43	<0.01	0.019	1.42		<0.005	3.85	0.09		<1	4 450	
.09	0.07	2.26	0.97		238	52.3	5.67	<0.3	217	1.06	<0.6	<0.05	<0.003	0.018	39.1	3 110	5.33	<0.01	0.026	1.27	9.0	<0.005	4.61	0.13	4.30	<1	4 780	4.10
.15	0.05	2.14	0.84		245	59.4	5.78	0.3	222	1.07	<0.6	<0.05	<0.003	0.018	42.7	2 800	5.08	<0.01	0.020	1.42		<0.005	4.85	0.12	4.80	<1	5 050	4.00
.23	0.04	2.19	1.00		269	68.4	6.30	<0.3	245	1.24	<0.6	<0.05	<0.003	0.018	43.8	2 320	5.83	<0.01	0.030	1.50		<0.005	5.66	0.16	5.40	<1	5 490	3.95
.27	0.08	1.98	1.12		295	65.4	6.40	<0.3	266	1.33	<0.6	<0.05		0.018	48.0	2 780	6.21	0.03	0.027	1.70		0.049	5.60	0.12	5.50	<1	5 720	4.00
.36	0.06	1.78	1.00	<0.2	295	71.1	6.47	<0.3	284	1.45	<0.6	<0.05	0.003		49.4	2 650	5.84	0.07	0.032	1.59		0.056	6.65	0.14	5.25	<1	5 800	4.00
.23	<0.01	1.58	0.87		325	77.5	6.74	<0.3	315	1.49	<0.6	<0.05	0.003		46.4	3 000	6.31	<0.01	0.027	1.95	3.2	0.038	5.96	0.15	5.40	<1	6 010	4.05
.36	0.04	1.39	0.89		328	88.4	7.80	<0.3	342	1.76	<0.6	<0.05			58.8	2 800	6.77	0.07	0.036	1.89		0.072	6.96	0.17	5.70	<1	6 200	3.95
.38	<0.01	1.14	0.83	<0.2	385	94.7	8.37	0.3	346	1.80	<0.6	<0.05	0.005		60.1	2 850	6.71	0.04	0.039	2.07		0.070	7.10	0.20	6.00	<1	6 330	3.85
.33	<0.01	1.16	0.83		437	95.4	8.14	<0.3	363	1.78	<0.6	<0.05			61.9	2 570	6.87	0.01	0.036	1.95		0.065	6.93	0.19	5.75	<1	6 370	4.10
.60	0.10	0.855	0.79	0.2	352	116.	10.6	0.5	417	2.40	<0.6	<0.05	0.003		68.4		8.02	0.18	0.040	2.07	1.6	0.150	8.85	0.18	6.00	<1	6 720	4.10

LINGAN BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION; ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

CYCLE	Ag	Al	As	B	Ba	Be	Ca	Cd	Cl	Co	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr
0	<0.005	2.75	0.010	0.795	0.199	<0.0005	101	<0.01	23	<0.05	<0.01	0.067	0.06	0.2	30	7.90	1.21	<0.3	35	0.08	<0.6	<0.05	<0.003	<0.003	3.60	280	0.445
1	<0.005	3.54	0.004	0.890	0.107	<0.0005	117	<0.01	21	<0.05	<0.01	0.110	0.09	0.8	36	9.70	1.64	<0.3	39	0.18	<0.6	<0.05	<0.003	<0.003	5.03	340	0.534
2	<0.005	3.99	0.006	0.850	0.055	0.0006	117	<0.01	18	0.08	<0.01	0.143	0.46	<0.1	34	10.0	1.87	<0.3	36	0.26	<0.6	<0.05	<0.003	<0.003	5.69	380	0.572
3	<0.005	4.57	0.017	0.768	0.073	0.0007	128	<0.01	22	0.10	<0.01	0.158	0.13	0.2	35	11.4	2.35	<0.3	37	0.37	<0.6	<0.05	<0.003	0.005	6.40	390	0.577
4	<0.005	5.84	0.042	0.868	0.056	0.0010	139	<0.01	22	<0.05	<0.01	0.196	0.13	<0.1	38	14.0	2.99	<0.3	41	0.48	<0.6	<0.05	<0.003	<0.003	9.27	480	0.802
5	<0.005	6.17	0.038	0.956	0.059	0.0008	147	<0.01	22	0.14	<0.01	0.213	0.14	<0.1	41	13.8	3.02	<0.3	39	0.56	<0.6	<0.05	<0.003	0.004	10.9	530	0.765
6	<0.005	8.95	0.025	0.956	0.081	0.0009	158	<0.01	18	0.15	0.14	0.256	0.40	<0.1	43	17.2	3.50	<0.3	130	0.72	<0.6	<0.05	<0.003	0.004	12.5	520	0.841
7	<0.005	8.52	0.030	0.954	0.064	0.0011	179	<0.01	20	0.17	0.11	0.295	0.33	0.5	45	18.2	4.11	<0.3	67	0.87	<0.6	<0.05	<0.003	0.011	13.3	800	0.979
8	<0.005	10.0	0.007	0.716	0.068	0.0017	173	<0.01	18	0.20	<0.01	0.337	0.25	<0.1	46	18.8	4.68	<0.3	44	0.94	<0.6	<0.05	<0.003	0.012	15.4	480	1.01
9	<0.005	11.0	0.005	0.751	0.070	0.0019	187	<0.01	22	0.26	<0.01	0.318	0.26	<0.1	51	20.2	5.13	<0.3	48	1.07	<0.6	<0.05	<0.003	0.011	17.0	740	1.13
10	<0.005	15.2	0.006	0.755	0.065	0.0022	216	<0.01	18	<0.05	<0.01	0.343	0.46	<0.1	56	23.9	6.16	<0.3	51	1.16	<0.6	<0.05	<0.003	0.010	19.0	770	1.36
11	<0.005	16.7	0.008	0.770	0.064	0.0029	218	<0.01	33	0.09	<0.01	0.411	0.45		56	24.3	7.45	<0.3	51	1.37	<0.6	<0.05	<0.003	0.014	20.4	870	1.53
12	<0.005	16.9	0.008	0.596	0.057	0.0028	232	<0.01	22	0.23	<0.01	0.405	0.44		58	25.7	7.14	<0.3	50	1.45	<0.6	<0.05	<0.003	0.011	22.5	810	1.46
13	<0.005	18.6	0.023	0.638	0.067	0.0030	241	<0.01	21	0.32	<0.01	0.508	0.72		60	26.2	7.39	<0.3	52	1.51	<0.6	<0.05	<0.003	0.011	24.8	700	1.55
14	<0.005	17.3	0.007	1.11	0.078	0.0027	256	0.01	23	0.32	0.01	0.413	1.58		65	27.4	7.29	<0.3	52	1.59	<0.6	<0.05		0.012	28.0	950	1.48
15	<0.005	17.5		1.10	0.054	0.0025	238	<0.01		0.37	<0.01	0.321	0.87		60	26.0	6.97	<0.3	49	1.49	<0.6	<0.05			29.5		1.50
16																											
17																											
18																											
19																											
20	<0.005	21.0		1.25	0.093	0.0033	256	0.02	22	0.42	0.06	0.273	0.44	0.1	65	29.3	8.25	<0.3	54	1.74	<0.6	<0.05	<0.003		46.3		1.75

LINGAN BOTTOM ASH SYSTEM

(CYCLE 0 REFERS TO SLURRY WATER BEFORE ASH ADDITION: ALL UNITS IN mg/L UNLESS OTHERWISE NOTED)

o	Cr	Cu	Fe	Hg (μg/L)	K	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Si	SO_4	Sr	Th	Ti	Tl	U (μg/L)	V	Zn	Zr	COND. (mS/cm)	ALK.	TDS	pH (units)
.05	<0.01	0.067	0.06	0.2	30	7.90	1.21	<0.3	35	0.08	<0.6	<0.05	<0.003	<0.003	3.60	280	0.445	0.06	<0.005	0.028	1.8	<0.005	0.18	<0.05	0.80	1	600	4.35
.05	<0.01	0.110	0.09	0.8	36	9.70	1.64	<0.3	39	0.18	<0.6	<0.05	<0.003	<0.003	5.03	340	0.534	0.08	<0.005	0.030	1.0	<0.005	0.30	<0.05	0.90	<1	680	4.20
.08	<0.01	0.143	0.46	<0.1	34	10.0	1.87	<0.3	36	0.26	<0.6	<0.05	<0.003	<0.003	5.69	380	0.572	0.07	<0.005	0.033		<0.005	0.20	<0.05	0.90	<1	1 050	4.20
.10	<0.01	0.158	0.13	0.2	35	11.4	2.35	<0.3	37	0.37	<0.6	<0.05	<0.003	0.005	6.40	390	0.577	0.08	<0.005	0.031		<0.005	0.26	<0.05	1.00	<1	800	3.90
.05	<0.01	0.196	0.13	<0.1	38	14.0	2.99	<0.3	41	0.48	<0.6	<0.05	<0.003	<0.003	9.27	480	0.802	<0.01	<0.005	0.026		<0.005	0.29	<0.05	1.10	<1	840	3.95
.14	<0.01	0.213	0.14	<0.1	41	13.8	3.02	<0.3	39	0.56	<0.6	<0.05	<0.003	0.004	10.9	530	0.765	<0.01	<0.005	0.024		0.008	0.38	<0.05	1.20	<1	1 070	3.90
.15	0.14	0.256	0.40	<0.1	43	17.2	3.50	<0.3	130	0.72	<0.6	<0.05	<0.003	0.004	12.5	520	0.841	0.01	0.005	0.008		<0.005	0.83	<0.05	1.29	<1	1 010	3.80
.17	0.11	0.295	0.33	0.5	45	18.2	4.11	<0.3	67	0.87	<0.6	<0.05	<0.003	0.011	13.3	800	0.979	<0.01	<0.005	0.012		<0.005	0.85	<0.05	1.25	<1	1 070	3.80
.20	<0.01	0.337	0.25	<0.1	46	18.8	4.68	<0.3	44	0.94	<0.6	<0.05	<0.003	0.012	15.4	480	1.01	0.02	<0.005	0.014		<0.005	0.52	<0.05	1.33	<1	1 170	4.05
.26	<0.01	0.318	0.26	<0.1	51	20.2	5.13	<0.3	48	1.07	<0.6	<0.05	<0.003	0.011	17.0	740	1.13	0.04	<0.005	0.017		0.010	0.55	<0.05	1.50	<1	1 210	3.80
.05	<0.01	0.343	0.46	<0.1	56	23.9	6.16	<0.3	51	1.16	<0.6	<0.05	<0.003	0.010	19.0	770	1.36	<0.01	<0.005	0.017		<0.005		<0.05	1.70	<1	1 280	3.74
.09	<0.01	0.411	0.45		56	24.3	7.45	<0.3	51	1.37	<0.6	<0.05	<0.003	0.014	20.4	870	1.53	<0.01	<0.005	0.020	0.4	<0.005	0.72	<0.05	1.55	<1	1 380	3.80
.23	<0.01	0.405	0.44		58	25.7	7.14	<0.3	50	1.45	<0.6	<0.05	<0.003	0.011	22.5	810	1.46	<0.01	<0.005	0.017		<0.005	0.74	<0.05	1.90	<1	1 460	3.78
.32	<0.01	0.508	0.72		60	26.2	7.39	<0.3	52	1.51	<0.6	<0.05	<0.003	0.011	24.8	700	1.55	0.05	<0.005	0.013		<0.005	0.80	<0.05	1.90	<1	1 470	3.70
.32	0.01	0.413	1.58		65	27.4	7.29	<0.3	52	1.59	<0.6	<0.05		0.012	28.0	950	1.48	0.02	<0.005	0.017		0.020	0.80	<0.05	2.00	<1	1 630	3.70
.37	<0.01	0.321	0.87		60	26.0	6.97	<0.3	49	1.49	<0.6	<0.05			29.5		1.50	0.03	<0.005		<0.2	0.021	0.81	<0.05	2.00			3.60
																									1.90			3.50
																									2.00			3.55
																									2.05			3.50
																									1.88			3.80
.42	0.06	0.273	0.44	0.1	65	29.3	8.25	<0.3	54	1.74	<0.6	<0.05	<0.003		46.3		1.75	0.08	0.007	0.031	0.4	0.047	0.88	<0.05	1.95	<1	1 730	3.70